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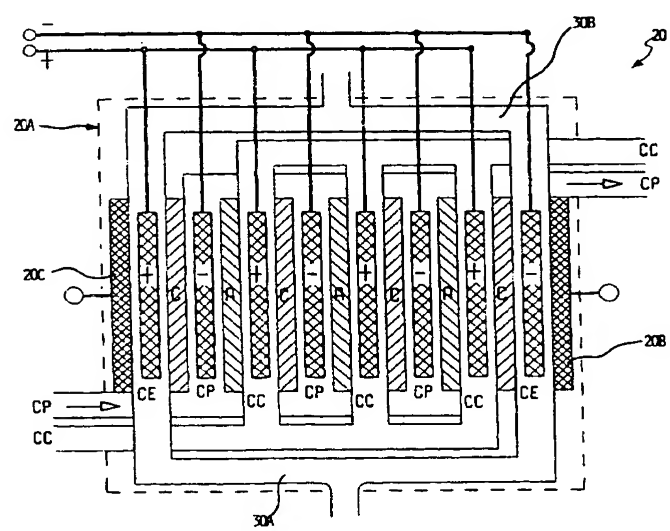

(57) Abstract: Arrangement for electrochemical purification or treatment of a liquid, utilizing an electrochemical cell (20), where two electrodes (20B,20C) are provided with ion exchange membranes (C,A) arranged between them to delimit a plurality of channels (CE,CC,CP). According to the invention, at least a few channels (CE,CC,CP) have respective second electrodes (+ ,-) associated to them for obtaining a cleaning substance or solution, the latter being apt to dissolve and/or remove likely residuals and/or scaling deposited inside the cell (20).

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ARRANGEMENT AND METHOD FOR ELECTROCHEMICAL PURIFICATION OR TREATMENT

DESCRIPTION

The present invention relates to an arrangement and electrochemical purification or treatment method, as featured in the preamble of the annexed claims 1 and 70.

It is the object of the present invention to provide a new efficient arrangement or purification or treatment device as above, which has a low cost, a long useful life and does not require maintenance operations.

These objects, and other aims to be further cleared hereafter, are provided according to the present invention by an arrangement or device and an electrochemical purification method or treatment as per the features of the annexed claims, which form an integral part of the description herein.

Further objects, features and advantages of the present invention will become more apparent from the following detailed description and annexed drawings, which are supplied by way of non limiting example, wherein:

- Fig. 1 shows a basic diagram of a first possible embodiment of a water purification system according to the present invention, in a non limiting application to a washing machine;
- Fig. 2 shows schematically a purification device pertaining to the system of Fig. 2, which is used for water softening or decalcification purposes;
- Figs. 3-5 show different views of a first component of a purification device manufactured according to a first possible embodiment of the invention;
- Figs. 6-9 show different views of a second component of a purification device manufactured according to a first possible embodiment of the invention;
- Figs. 10-13 show different views of a third component of a purification device manufactured according to a first possible embodiment of the invention;
- Fig. 14 shows a partial exploded view of a purification device manufactured by means of the components of the Figures 3-13;
- Figs. 15-17 show different views of a first component of a purification device manufactured according to a second possible embodiment of the invention;
- Figs. 18-21 show different views of a second component of a purification device

manufactured according to a second possible embodiment of the invention;

- Figs. 22-25 show different views of a third component of a purification device manufactured according to a second possible embodiment of the invention;
- Fig. 26 shows a partial exploded view of a purification device manufactured by means of the components of the Figures 15-25;
- Fig. 27 shows a partial exploded view of a component of a purification device manufactured according to a third possible embodiment of the invention;
- Fig. 28 shows a plan view of an element pertaining to the component of Fig. 27;
- Fig. 29 shows a partial exploded view of a purification device comprising the component of Fig. 27;
- Figs. 30-32 show different views of a component of a purification device manufactured according to a fourth possible embodiment of the invention;
- Fig. 33 shows a partial exploded view of a purification device comprising the component of Figures 30-32.

The device and method according to the invention will be further described by way of non limiting example of their advantageous utilization for the softening or purification at least of a portion of the water used by a household apparatus. The invention is also capable of advantageous use for other purposes in a household appliance, such as a recirculation system of the water already utilized for the washing as well as in other hydraulic systems or circuits for the electrochemical treatment of liquids or substances, in particular for reducing or removing periodical maintenance operations, through automatic washing with highly acid or highly basic substances, in order to remove likely deposits or rests eventually formed or deposited inside the system.

In main line, the invention is capable of advantageous use in hydraulic systems or circuits for the electrochemical treatment of liquids or substances requiring technical solutions for simplifying their structure and/or reducing their costs and/or increasing their life without the need of maintenance.

In Fig. 1, reference 1 indicates schematically a treatment container or wash tub of a washing machine, comprising a treatment or purification system of a liquid according to the present invention, where at least a substance has to be detracted from at least a portion of the liquid; in the above example, the system is provided at least for reducing water hardness.

The washing machine illustrated above is a standard dishwasher, with the spraying means of the wash liquid represented by two common rotary spraying arms 2 and 3 arranged in the wash tub 1; reference 4 indicates a common wash pump or circulating pump for sucking the wash liquid from the bottom of the tub 1 and convey it to the arms 2 and 3 through an appropriate duct 5.

Reference 6 indicates a common discharge pump for discharging the liquid utilized in the tub; to this purpose, an appropriate outlet hose 7 is connected to the pump outlet 6. Reference 8 indicates a duct fitted with an inlet valve 9 for water intake from a household water system; the valve 9 is a common valve controlled by the machine control system for supplying the clean water required for washing according to appropriate times and procedures; sensing means may be provided on the duct 8 as schematically indicated with MS, which are apt to detect various operating parameters of the inlet water, such as flow-rate, pressure, conductivity or resistivity, temperature, hardness, acidity or pH degree, etc.

The duct 8 downstream of the valve 9 has a so-called air-break device or check valve indicated with AB; downstream of the air-break AB, the duct 8 branches out in two separate ducts 8A and 8B, which supply a first tank P and a second tank S, respectively. Common valves 10 and 11 controlled by the machine control system are provided upstream of the inlets of the tanks P and S, along the above ducts 8A and 8B, respectively.

The tanks P and S comprise each one appropriate sensing means; the sensors SP1 and SS1 are provided for detecting "quantitative" features of the water in the tanks P and S, such as flow-rate, pressure, level, temperature, etc., whereas the sensors SP2 and SS2 will detect "qualitative" or electrochemical features of the water in the tanks P and S, such as conductivity or resistivity, hardness, acidity or pH degree, etc.

The tank P has a first outlet P1 communicating with the suction branch of a common pump 12 controlled by the machine control system, and a second outlet P2, communicating with a water inlet duct 13 to the tub 1 of the machine; a common valve 14 controlled by the machine control system operates at the outlet P2 of the tank P, which also comprises an appropriate filter PF in line with the outlet P1.

Also the tank S has two outlets, the first one indicated with S1 communicating with the suction branch of a common pump 15 controlled by the machine control system, whereas the second outlet of the tank S, indicated with S2, communicates with the above water inlet duct 13 to the tub 1 of the machine; a common valve 16 controlled by the machine control

system operates at the outlet S2 of the tank S, which also comprises an appropriate filter SF in line with the outlet S1.

It will be noticed how the various valves of the system described above are normally closed electric valves; therefore, for the purposes of the description herein, these valves should be considered in their closed condition, save when otherwise specified.

Reference 20 indicates a purification device in its whole, also mentioned as a decalcifier or softener in the following, operating with an electrochemical cell or by electro-dialysis or electro-osmosis, which has two inlet ducts 21 and 23 in its lower section, and two outlet ducts 22 and 24 in its upper section.

The inlet duct 21 is hydraulically connected to the delivery branch of the pump 12, whereas the inlet duct 23 is hydraulically connected to the delivery branch of the pump 15; the outlet duct 22 is hydraulically connected to the tank S or to the duct 8B at a location downstream of the valve 10; the outlet duct 24 is hydraulically connected to the tank P or to the duct 8A at a location downstream of the valve 11.

The decalcifier 20 may comprise appropriate sensing means, not represented in the figures, for detecting various "quantity" and/or "quality" operating parameters, such as the flow-rate, pressure, conductivity or resistivity, temperature, hardness, acidity or pH degree of the water being supplied to or discharged from the decalcifier 20, and so on.

Fig. 2 illustrates a more detailed schematic description of the purification or decalcifier device 20. This schematic representation is exclusively intended by way of non limiting example, where some details may be missing or in excess, or manufactured in a different way, but subject to obtain analogous operations or performances as provided by the present invention.

In particular, the purification device or decalcifier 20 may provide different hydraulic configurations compared to the ones represented herein, such as parallel and in series connections between the various channels of the cell, and/or different types or arrangements of the various elements, such as the ion exchange membranes described hereafter.

The device 20 comprises a body 20A, e.g. made from thermoplastic material, in which respective main electrodes are arranged on both lengthwise ends, in particular a positive electrode or anode indicated with 20B, and a negative electrode or cathode indicated with 20C.

Appropriate common ion exchange membranes are assembled between the anode 20B and cathode 20C, delimiting a set of ducts inside the body 20A.

In particular, reference A indicates some membranes permeable to the anions, i.e. to the ions with one or more negative electric charges, which in an electro-dialysis process or anyway under the effect of an electric current or voltage migrate to an anode; reference C indicates some membranes permeable to the cations, i.e. to the ions with one or more positive electric charges, which in an electro-dialysis process or anyway under the effect of an electric current or voltage migrate to a cathode.

As it will be noticed, the membranes A alternate to the membranes C, delimiting inside the body 20A:

- two "electrodes channels", indicated with CE, which in the non limiting example of Fig. 2 extend each one from the anode 20B to a membrane C, and from the cathode 20C to a membrane C, respectively;
- at least a "concentrate channel" CC, delimited by a membrane C and a membrane A; in the example three channels CC are provided;
- at least a "product channel", indicated with CP, extending from a membrane A to a membrane C; in the example three channels CP are provided.

Moreover, in the embodiment represented above,

- the channels CE are connected in parallel to each other by means of an inlet manifold 30A and outlet manifold 30B;
- the channels CC are connected in parallel to each other, both on their lower and upper ends, at the inlet duct 23 and outlet duct 22, respectively;
- the channels CP are connected in parallel to each other, both on their lower and upper ends, at the inlet duct 21 and outlet duct 24, respectively.

Always referring to Fig. 2, the symbols "+" and "-" indicate intermediate electrodes located in line with the channels CC and CP; in particular, intermediate electrodes "+" with a positive polarity are provided in line with the channels CC, whereas intermediate electrodes "-" with a negative polarity are provided in line with the channels CP; an intermediate electrode "-" with a negative polarity is provided in the channel CE related to the anode 20B, whereas an intermediate electrode "+" with a positive polarity is provided in the channel CE related to the cathode 20C. The above intermediate electrodes "+" and "-" are preferably connected to pairs with alternate polarity connected in parallel to each

other, so as to form an alternance of positive and negative polarities.

As it will be further cleared, these intermediate electrodes "+" and "-" are utilized for producing an acid directly from the water flowing in the purification device 20 for cleaning purposes of the latter.

Back to Fig. 1, reference 31 indicates a pump similar to the previous pumps 12 and 15, whose delivery side communicates with the manifold 30A through a duct 32; the suction branch of the pump 31 is connected to the outlet manifold 30B through a duct 33; a tank 34 is preferably provided along the duct 33.

According to an implementation not represented, inlet and outlet ducts may be provided with relevant solenoid valves and sensing means also for the hydraulic circuit related to the tank 34, in order to supply and/or discharge the circulating liquid on the electrodes of the device 20 and/or detect its features. In this frame, the tank 34 may have a configuration like the tanks P and S, i.e.:

- communicate with the duct 8, through a relevant inlet and solenoid valve (not illustrated) similar to the ducts 8A, 8B or valves 10, 11,
- communicate with the wash tub 1 through a relevant outlet and solenoid valve (not illustrated) similar to the outlets P2, S2 or valves 14, 16,

for periodic replacement of a washing liquid for the electrodes contained in the tank 34 and/or in the hydraulic circuit related to the electrodes 20B and 20C.

The dishwashing machine described above operates as follows.

For the purposes of this operation it is assumed that also the tank 34 has relevant inlet and outlet controlled by respective solenoid valves, as mentioned above.

Fig. 1 illustrates a water intake condition from the water system; for instance, this stage may be the first intake step provided by a normal wash cycle of the machine incorporating the invention.

To this purpose, the machine control system will provided

- open the valves 9, 10, 11 and inlet valve of the tank 34,
- maintain the valves 14, 16 and outlet valve of the tank 34 closed,
- maintain the pumps 12 ,15 and 31 deactivated.

The water supplied from the water system can flow through the duct 8, overcome the air-break AB and then flow to the tanks P and S through the ducts 8A and 8B, as well to the tank 34 through the relevant inlet.

Enough water is supplied to the tanks P, S and 34 for the purpose to be further cleared, thereafter the valves 9, 10, 11 and inlet valve of the tank 34 are closed; it should be noticed how with the closure of the above valves, water dosage inside the tanks P, S and 34, can be obtained through any known technique; to this purpose, each tank P, S and 34 may be fitted with relevant level sensing means (e.g. pertaining to SS1 and SP1), such as a floating sensor, pressure regulator or, preferably, a commonly known turbine flow meter.

During water intake of the tanks P, S and 34, the control system will also control the water features through the sensors MS and/or SS2, SP2, being apt to detect water conductivity or resistivity and/or hardness and/or acidity or pH degree, etc., so as to automatically establish the amount of water required and whether it should be treated through the softening system or directly discharged from the tanks P and/or S into the wash tub 1.

In particular, the amount of water to be supplied to the tank S is automatically changed by the control system proportionally to the hardness of the water to be treated, i.e. the water coming from the duct 8.

Should water hardness exceed the preset limits, it would first be left to rest for a given period of time, e.g. a few minutes, during which likely impurities in the water can decant and deposit on the lower pit-like areas of the tanks P and S; these impurities may be e.g. sand, iron rests, rust, and so on.

After the above "decanting" period of time has elapsed, the control system of the machine supplies the pumps 12, 15 and 31.

Thus, the water in the tank P is flown to the channels CP of the decalcifier 20 through the duct 21, and then back to the tank P through the duct 24 due to the closed valve 11; the same applies for the water in the tank S, which is conveyed to the channels CC of the decalcifier 20 through the duct 23, and then back to the tank S through the duct 22 due to the closed valve 10; the pump 31 causes recirculation of a wash liquid for the electrodes 20B and 20C, e.g. water, in the relevant closed circuit.

As the pumps 12, 15 and 31 are activated, the machine control system will simultaneously apply direct voltage between the anode 20B and cathode 20C of the decalcifier 20.

Thus, the electric current flowing across the decalcifier 20 induces migration of the Calcium and Magnesium cations contained in the water flowing in the channels CP to the cathode 20C through the membranes C permeable to the cations, whereas due to the electric current the anions will migrate to the anode 20B through the membranes A

permeable to the anions.

In this situation, the membranes C permeable to the cations hinder the anions from proceeding to the anode 20B and the membranes A permeable to the anions hinder the cations from proceeding to the cathode 20C. This process leads to a gradual reduction of cations concentration inside the channels CP; in particular, as far as the purposes of the example are concerned, the cations causing water hardness, such as Calcium and Magnesium cations in the channels CP, will gradually transfer to the channel CC and channel CE of the cathode 20C.

Thus, during the softening process, some Calcium and Magnesium cations also migrate to the channel CE corresponding to the cathode 20C, from the channel CP adjacent to it, flowing across the cationic membrane C, which separates said channels from each other; as a result, the washing liquid of the electrodes will be enriched with these cations.

Subsequently, during recirculation of the washing liquid of the electrodes performed by the pump 31, the same Calcium and Magnesium cations will reach the channel CE corresponding to the anode 20B; as a result, these cations will be induced to migrate by electrolytic or electrochemical effect to the channel CC adjacent to said channel CE of the anode 20B, across the cationic membrane C, which separates said channels from each other; the above Calcium and Magnesium cations are detracted from the washing liquid of the electrodes and flow to the water of the tank S recycled through the pump 15.

This solution hinders an excessive concentration of Calcium and Magnesium cations in the circuit of the washing liquid of the electrodes, reducing the frequency of replacement of that fluid or reducing anyway the quantity required to avoid exceeding the precipitation threshold due to extreme concentration.

Therefore, as it can be noticed, in a possible embodiment of the system according to the present invention, the electrochemical or electro-dialysis softening process is preferably performed with circulation of the same water inside the purification device 20, for obtaining a gradual reduction of ions concentration in the water or liquid contained in the tank P, that flows in the channels CP and, also, cause a gradual concentration increase of the ions contained in the water or fluid inside the tank S, flowing in the channels CC.

The softening or purification process and, consequently, the above water recirculation between the tanks P and S and the purification device 20, as well as water recirculation between the tank 34 and purification device 20, can be timed, i.e. for a preset period of

time, or its duration can be programmed for a given number of water passes through the device 20. Advantageously, this time or preset number of passes may change depending on the hardness degree of the water entering the machine, such as detected by the sensing means MS. The machine control system may be advantageously programmed also to avoid performing the softening process, should the hardness of the water intake measured by the sensing means MS be sufficiently low or below a preset value.

Upon terminating the decalcification process, the control system stops supplying the above electric voltage between the anode 20B and cathode 20C, as well as power supply to the circulating pumps 12, 15 and 31; therefore, the water inside the tank P will be purified or softened (also called Product in the following), whereas the tank S will contain water (also called Concentrate in the following) with an increased ions contents (cations and anions), also including calcium and magnesium cations contributing to produce hardness.

It should be noticed how the hydraulic system previously described is so conceived to have at least the various channels of the device 20 practically always filled with water, also after interrupting operation of the pumps 12, 15 and 31; thus, also during the resting or deactivation steps of the device 20, a certain amount of water is maintained inside the latter, so as to ensure that the membranes C and A remain immersed in water or are maintained humid, and avoid that such membranes may dry up and become deteriorated.

At the end of the above decalcification process, the machine control system will open the valve 14.

Thus, the water contained in the tank P can flow to the duct 13, and from it to the machine tub 1; it should be noticed how the first portion of this water reaching the tub 1 contains the impurities eventually deposited on the bottom of the tank P; anyway, these impurities can be trapped by means of a further filtering system of the apparatus or prove irrelevant for typical dishwasher operation.

Washing of the crockery will be performed through the pump 4, circuit 5 and sprayer arms 2 and 3 according to common procedures, followed by a discharge of the liquid utilized in the tub 1, obtained by activation of the pump 6; to this purpose, the control system is obviously preset for supervising to the typical washing machine operation.

Once discharge is over, the machine control system will execute a new water inlet from the water system for performing the second step provided by the wash cycle.

In a non limiting example of the operation cycle, the machine control system will open the

valves 9 and 11 alone, maintaining closed the valve 10 as well as the valves 14 and 16; during this step, the pumps 12, 15 and 31 are deactivated. The water supplied from the water system can flow along the duct 8, overcome the air-break AB and then flow to the tank P through the duct 8A; as it can be noticed, the tank S and tank 34 contain the water utilized in the previous cycle step for decalcification purposes.

As soon as the tank P is filled with the required amount of water, the valves 9 and 11 will close and the water supplied to the tank P is left to "decant" as explained above; thereafter, the machine control system will power the pumps 12, 15 and 31.

Then, the water in the tank P is conveyed through the duct 21 to the channels CP and back to the tank P through the duct 24 due to the closure of the valve 11; the water in the tank S is conveyed through the duct 23 to flow in the channels CC and then back to the tank S through the duct 22 due to the closure of the valve 10.

Upon activating the pumps 12, 15 and 31, the machine control system will simultaneously apply the direct voltage mentioned above between the anode 20B and the cathode 20C of the decalcifier 20, in order to decalcify the water contained in the tank P according to the procedures previously described. This softening process under consistent recirculation causes a gradual hardness abatement of the water of the tank P flowing in the channels CP; on the other side, the same process provides a further gradual hardness increase of the water of the tank S.

Upon terminating the decalcification process, the control system will stop applying the above electric voltage between the anode 20B and cathode 20C, as well as power supply to the circulating pumps 12, 15 and 31; as a result, the water inside the tank P will be softened, whereas the water in the tank S contains an increased contents of calcium and magnesium cations.

The machine control system will open the valve 14 for the water contained in the tank P to flow to the duct 13 and reach the machine tub 1; washing of the crockery is performed as for the previous step, according to common procedures.

The same water intake and decalcification process previously described is then repeated for all the steps provided by the wash cycle.

From the above it is obvious how according to the solution provided, the same water originally supplied to the tank S is utilized for performing several water softening steps of the water supplied from time to time to the tank P; the solution according to the present

invention will reduce to a substantial extent the amount of reject water from the decalcification process. As an alternative, the tank S may be emptied and subsequently filled with water from the water system concurrently with every emptying and filling cycle of the tank P; in this case, the amount of water supplied each time to the tank S will be less compared to the example previously described, but such to receive the substances extracted from the liquid contained in the tank P; however, no extreme concentration nor precipitation will occur.

The water contained in the tank S for performing the decalcification processes during the various water supplies from the water system can be discharged from the machine at the end of a wash cycle. A possible advantageous embodiment of the present invention, on the other hand, will maintain the water contained in the tank S at the end of a wash cycle either in the tank itself or in the wash tub for its further use during a subsequent operation of the apparatus or subsequent wash cycle step. The contents of the tank S may also be utilized for performing determined steps provided by a wash cycle whenever the use of water with a high hardness degree is acceptable for such steps, such as the cycle steps executed with cold water or with water having a lower temperature than the precipitation threshold of limestone.

In the preferred embodiment of the invention, several pairs of cationic membranes C and anionic membranes A (e.g. thirty pairs) are provided in order to manufacture the decalcifier 20, with addition of a terminal cationic membrane, in order to have only cationic membranes C facing the end electrodes 20B and 20C. The use of membranes of the same type, such as cationic (but could also be anionic) on both ends of the decalcifier 20 allows the ions, in the present example the cations, transferred from the last channel CC to the channel CE of the cathode 20C to be expelled to the opposite channel CC, when circulating in the channel CE of the anode 20B.

The control system of the device according to the invention may be advantageously programmed to realize polarity inversion at regular intervals of the end electrodes 20B and 20C of the decalcifier 20.

In a possible embodiment, the above polarity inversion may occur for a fixed period of time at the end of each decalcification process (e.g. for a time equalling 10% of the total treatment time); in these conditions, the water will be softened and clean in the channels CP, where scale may form on the surfaces of the membranes C and A, whereas the water in

the channels CE and CC have an enriched contents of Calcium and Magnesium cations.
At any rate, other operating procedures may be provided, such as more polarity inversions during the whole decalcification process, adopting fixed or variable periods of time based on continuous measurement of water hardness through the means MS, SS2 and SP2 of the water supplied from the system to the tank S and to the tank P.
In a preferred embodiment, referring to the above polarity inversion of the electrodes 20B and 20C, the softening system described is also conceived for alternating the operations of the tanks S and P or changing the hydraulic configurations, in order to obtain inverted circuits.
As previously noticed, the tank P is shown in normal conditions for containing the water to be softened, whereas the tank S is provided for the reject water of the decalcification process; however, according to the suggested implementation, the above polarity inversion of the electrodes may also occur not just for one portion alone of a decalcification process, but rather for its whole duration. According to this embodiment, to said inversion of electric polarities correspond also an inversion of the hydraulic circuits and/or relevant operations; i.e. a decalcification process as previously described, where the electrode 20B is acting as the anode and the electrode 20C as the cathode, the tank P collects the water to be softened and the tank S collects the water with the migrating cations of the water of the tank P, will be followed by a decalcification process with inverted polarity and inverted channels CC and CP, where the electrode 20B is acting as the cathode and the electrode 20C as the anode, the tank S collects the water to be softened and the tank P collects the water with the migrating cations of the water of the tank S.
In this process, after filling the tanks P and S, and a subsequent "decanting" period of time. the machine control system will activate the pumps 12, 15 and 31. Thus, the water in the tank P is conveyed to the channels CP of the decalcifier 20 through the duct 23 and then back to the tank P through the duct 24, due to the closure of the valve 11; the same applies for the water in the tank S, which is conveyed to the channels of the electrodes CE and channels CC of the decalcifier 20 through the duct 21, and then back to the tank S through the duct 22, due to the closure of the valve 10.
Simultaneously to activation of the pumps 12, 15 and 31, the machine control system will apply a direct voltage between the electrode 20B, now acting as a cathode, and the electrode 20C, now acting as the anode.

Thus, the electric current flowing across the decalcifier 20 induces migration of the Calcium and Magnesium cations contained in the water flowing in the channels CC to the electrode 20B, through the membranes C permeable to the cations, whereas electric current causes the anions to migrate to the anode 20C, through the membranes A permeable to the anions. In this situation, the membranes C permeable to the cations hinder the anions from proceeding to the electrode 20C and the membranes A permeable to the anions hinder the cations from proceeding to the electrode 20B. This process leads to a gradual reduction of cations concentration inside the channels CC; in particular, for the purposes of the present invention, the Calcium and Magnesium cations in the channels CC will gradually transfer to the channels CP and channels CE of the electrode 20B, according to the same procedures previously described.

As it will be noticed, also in this case the electrochemical softening process or by electro-dialysis is obtained with the water circulating inside the decalcifier 20; this occurs to ensure a gradual hardness reduction of the water in the tank S and, conversely, a gradual hardness increase of the water in the tank P flowing in the channels CP.

The electrochemical purification process previously described may cause salts precipitation inside the channels of the decalcifier 20, and a consequent clogging. For this reason, according to the main feature of the present invention, an electrochemical self-cleaning system of the decalcifier itself is provided, to be actuated for a short period of time when clogging occurs or anyway timely enough before the decalcifier 20 undergoes a performance decay.

The precipitate forming inside the various channels of the decalcifier 20 is mainly due to water insoluble Calcium and Magnesium salts; however, these salts are soluble in an acid environment.

The intermediate electrodes "+" and "–" previously mentioned pertain to the above electrochemical self-cleaning system; in particular, they operate to form a cleaning acid directly inside the purification device 20, i.e. in the channels where ions concentration tends to increase and the above precipitated salts tend to collect.

In the previous example, where a first purification cycle concentrating the ions in the channels CC and in one of the channels CE, and a second purification cycle with an inverted purification concentrating the ions in the channels CP and in the other channel CE are performed, execution of two separate self-cleaning cycles will be required, forming the

acid in the last channels that have undergone a ions concentration increase.

Preferably, the intermediate electrodes "+" and "–":

- are alternated for operating in pairs (+ and -) on one type alone of both membranes A or C, preferably cationic membranes C, being more resistant to the electrochemical action;
- are manufactured at low cost, preferably from plastic or electrically conductive rubber, or conductive material fibres, such as graphite or carbon, since the number of these intermediate electrodes is a high one and the number of their working hours relatively low;
- are manufactured with a form and/or material such not to create a preferential or short-circuit path for the current circulating between the main electrodes 20B and 20C of the device 20; vice-versa, the electric current would no longer flow in the liquid solution (Product and Concentrate, where the concentrate has a higher electric conductivity), finding a preferential path in the thickness of the intermediate electrodes "+" and "–"; according to the invention, this drawback is avoided manufacturing the intermediate electrodes "+" and "–" with a material having a higher electric resistance than the one of the above solution (Product and Concentrate) and/or ensuring a gap between the intermediate electrode and ion exchange membrane, so that the liquid to be treated may circulate in such a gap.

Therefore, by way of mere indication, the intermediate electrodes "+" and "–" may:

- have a net form or anyway a porous structure allowing the liquid and/or the ions to flow across, also operating as spacers or supporting walls for the ion exchange membranes, or
- have a composite structure, e.g. partially from electric conductive plastic and partially from electric conductive net or tissue (such as carbon fibre or graphite or other electric conductive material suitable for the purpose), said portions being maintained or pressed together for electric contact, or glued, welded, co-moulded, or
- be made from electric conductive plastic over-moulded to a metal core, for improving even current distribution in the long paths, or
- be solidly connected or anyway paired to the ion exchange membranes, and then put in contact with one or more electric contacting or distribution rods or elements, such as made from electric conductive plastic co-moulded with a respective membrane electric isolating support element; also for the latter configurations all the materials and/or

manufacturing technologies previously described or apt to the purpose may be provided.

Some manufacturing examples of the above intermediate electrodes "+" and "-" are described hereafter.

With reference to the configuration indicated in Fig. 2, in the system according to the invention, from a chemical standpoint, application of an electric voltage to the intermediate electrodes "+" and "-" of the purification device 20 produces the following phenomena:

<u>Concentrate Channels CC (with intermediate electrodes "+" with positive polarity)</u>

In these channels acid is formed according to the following reaction:

$$2\,H_2O \rightarrow 4\,H^+ + O_2 + 4\,e^-$$

i.e. a sort of oxidation, where two water molecules produce four hydrogen H^+ ions (causing acidity), with simultaneous formation of one oxygen (O_2) molecule, which is released in the air (or eventually commonly catalysed for its recombination in water).

According to this reaction, the channels CC will have an acid environment; this acid solution is used for dissolving the salts deposits inside the purification device 20 (e.g. $CaCO_3$, $MgCO_3$,) according to the following reaction:

$$MCO_3 + 2\,H^+ \rightarrow M^{2+} + CO_2 + H_2O$$

where M^{2+} is the general bivalent cation causing precipitation of the above salts (Ca^{2+}. Mg^{2+}).

In order to obtain a high concentration of hydrogen H^+ ions required for dissolving the above saline deposits, during the self-cleaning cycle, the channels CC operate preferably under static conditions, i.e. without hydraulic recirculation in the decalcifier 20.

<u>Product Channels CP (with intermediate electrodes "-" with negative polarity)</u>

In these channels a base is consequently formed according to the following reaction:

$$2\,H_2O + 2\,e^- \rightarrow 2\,OH^- + H_2$$

i.e. a sort of reduction, where two water molecules produce two oxidrilic OH^- ions (causing basicity), with simultaneous formation of an hydrogen (H_2) molecule, which is released in the air (or eventually commonly catalysed for its recombination with the oxygen O_2 molecule previously mentioned, in order to form water and avoid gas release in the environment).

Therefore, according to this reaction, the Product channels CP will have a basic environment (high pH); this basic solution may favour a further precipitation of the cations

with a low concentration in the channels CP, with production of MCO_3 and $M(OH)_2$.

In order to avoid or reduce this pH increase and consequently the risk of cations precipitation in the solution, during the self-cleaning cycle the channels CP (inversely to the above channels CC) operate preferably with activated hydraulic recirculation (dynamic conditions), for diluting the OH^- ions produced in the few cubic centimeters of solution contained in the purification device 20 in the large amount of water in the recirculation tank P.

Thus, whenever a high acid concentration is desired (channels to be washed), the liquid is preferably maintained in static conditions in the device 20, whereas for a low basic concentration (opposite channels, to avoid undesired precipitations) circulation will be maintained.

When using a polarity inversion for the decalcification cycle (where to an electric inversion of the electrodes 20B and 20C as previously described an hydraulic inversion of the channels CC and CP will correspond – in the sense that the Product channels are now Concentrate channels and vice-versa), the control system will store the information related to the last polarity utilized so as to know which have been the last Concentrate channels or the last channels with an increased ions concentration, and the last Product channels or last channels with a reduced ions concentration; also for the two Electrode channels CE it is important to know the last polarity utilized, since Calcium and Magnesium tend to collect more on the last electrode with negative polarity that has been used.

With a polarity inversion of the electrodes 20B and 20C, the rests or precipitates will anyway collect in all the channels of the decalcifier 20, and this requiring a first self-cleaning cycle with acid of a first set of channels (e.g. the last ones utilized for the Concentrate) and a second self-cleaning cycle with acid of a second set of channels (e.g. the last ones used for the Product, which have also previously operated as Concentrate channels in other decalcification cycles).

Preferably, said first and second self-cleaning cycle are not performed subsequently to each other for the reasons to be cleared hereafter, but they are performed each one after a respective operation cycle of the device 20 as a purification system, to have the ions enriched solution or Concentrate flowing in the channels to be cleaned, where acid is formed, whereas in the opposite channels, where the basic solution is formed, there is purified water.

In order to perform the first of said self-cleaning cycles, the intermediate electrodes "+" "-" are connected with a first type polarity, whereas for performing the second of said self-cleaning cycles, the intermediate electrodes "+" "-" are connected with a polarity opposite to the previous one.

As previously said, in the non limiting example of Fig. 2, the intermediate electrodes "+" "-" are preferably connected to pairs with alternate polarity, connected in parallel to each other for creating an alternance of positive and negative polarities; this configuration allows the use of a low direct voltage, particularly useful in the household environment for avoiding possible electric shocks due to accidental leaks; in alternative, other suitable electric connections may also be obtained.

The above self-cleaning treatment of the decalcifier 20 is preferably but not necessarily performed with the same aqueous solution present in the various channels CE, CC and CP at the end of the purification treatment, where the Concentrate and Electrodes channels are enriched with the ions extracted from the Product channels, which remain consequently impoverished.

In these conditions, the lack of ions in the Product channels CP, where water would tend to become basic during the self-cleaning treatment (even if such a phenomenon is reduced by circulation), will consequently reduce the risk of salts precipitation; vice-versa, precipitation does not occur in the Concentrate, also in the presence of many ions, due to the formation of an acid during the self-cleaning treatment.

For this reason and the need of washing all the ducts that have operated alternated from time to time during operation with inverted polarity, it is appropriate for the system to perform a washing according to a first procedure (first configuration of the Product and Concentrate channels) at the end of a decalcification terminating with a first polarity, followed by a further washing according to a second procedure (opposite configuration of the Product and Concentrate channels) at the end of a further decalcification terminating with a second opposite polarity.

It should be noticed how the above ions depletion in the Product channels causes a minor conductivity of the relevant liquid, whereas a ions increase in the Concentrate channels causes a higher conductivity of the relevant liquid.

When decalcification is over, an electric circuit is produced (between the two end electrodes 20B and 20C or between the intermediate electrodes "+" "-"), which consists of

an alternate high value (Product) and low value (Concentrate) resistances set (ohm), also comprising the interlaying of the electric resistances introduced by the ion exchange membranes C and A; membranes resistance has a relatively consistent value compared to the electric resistance of the liquid, which changes depending on the displacement of ions concentration.

As to these resistance changes, the increased of the resistance of the Product channels (ions depletion) is proportionally higher or different from the relevant reduction of the resistance of the Concentrate channels (higher ions concentration); thus, the total resistance of the Product and Concentrate resistances sets will increase with the decalcification progress (as the ions unbalance between said channels gradually increases).

However, it should be noticed how in the household and/or food field the achievement of extremely low purification or conductivity values (total removal of the ions or dissolved salts) is not required, if not at all forbidden.

Therefore, according to the example of the present invention, the decalcified water remaining in the Product channels still maintains a residual hardness, which allows electric current circulation between the intermediate electrodes "+" "-", in order to obtain the electrochemical phenomena described above, which are apt to produce the cleaning acid without the risk of starting said precipitation phenomena.

The control system supervising the operation of the device 20 will be programmed for activating the above self-cleaning cycle depending on the various conditions and/or actual requirements, such as performing various measurements by means of sensors (hardness, flow, and so on), and/or storing and elaborating the data related to the previous purification operation of the device itself, such as detecting any changes in the flow-rates and/or electric absorptions, or changing the self-cleaning cycle in relation to the previous purification cycle.

In a possible embodiment, a flow sensor is provided to this purpose, preferably one sensor for each hydraulic circuit (CC, CP, CE), being apt to detect the changes of the liquid flow-rate circulating in the various channels of the electrochemical cell, detecting a likely clogging caused by deposits or precipitates, and activate the self-cleaning cycle only if actually required.

Preferably, the control system verifies said information from the flow meter or flow meters provided and elaborates them, e.g. jointly with other data associated to likely minor electric

absorptions of the device 20 (attributable, for instance, to deposits on the ion exchange membranes), in order to activate or not the self-cleaning cycle.

In other conditions, as in the instance of bio-films formation (proliferation of biologic films in stagnant water conditions), it may be preferable to perform an early self-cleaning and/or disinfection cycle, even if a likely low inlet water hardness may not require it.

According to a possible implementation of the purification device 20, it should be noticed how the channels CE may not have any intermediate electrodes "+" "-". In this embodiment, the missing intermediate electrodes are actually replaced by the two end electrodes 20B and 20C normally utilized for decalcification; in this embodiment, the electrodes 20B and 20C are connected to the intermediate electrodes of equal polarity through a special switching circuit, consisting e.g. of switches or electronic switches.

The self-cleaning cycle of the device 20 preferably provides for maintaining the "+" and "-" electrodes solution for a short period of time inside the various channels CE, CC and CP, and have it evacuated by means of the new liquid supplied to the channels for flushing; for instance, this new rinsing liquid may be supplied to the channels CE, CC and CP through the same means and procedures described with reference to machine operation of Fig. 1.

For instance, such a flushing may be performed with clean water or reject water (i.e. pertaining to the circuit of the tank S), in order to evacuate the cleaning solution or acid and any rests/scales dissolved there; this flushing liquid of the device 20 can be discharged into the tub 1 or directly into the outlet duct of the machine 7, along with the cleaning solution for the device 20.

It should also be underlined how the cleaning of the device 20 according to the invention is in no way comparable to a resins regeneration provided for conventional decalcifiers; according to the present invention, the substance or solution used is actually provided for dissolving likely scaling or deposits on the walls of the ion exchange membranes, whereas in the instance of a resins softener the ions of the regenerating compounds (usually a water and salt solution) will remove and replace the ions previously absorbed and retained by the resins.

As said, the self-cleaning cycles of the device 20 are possible and anyway performed automatically only at regular intervals when a clogging or nearly clogging situation of the device is detected or estimated (e.g. at time intervals of decades of operative days of the washing machine represented in Fig. 1, if the latter is used several times a day with highest

hard water levels, as per the field specifications); moreover, the through-section of the various channels CE, CC and CP is extremely reduced (in the order of a few millimeters); as a result, the amount of wash solution to be used for each self-cleaning cycle of the device 20 is very restricted (e.g. in the order of some tens of cubic centimeters of concentrated acid, further diluted in the water supplied by the hydraulic circuit).

Figures 3-14 represent some of the components utilized for obtaining a first embodiment of the purification device or decalcifier 20; in these figures the intermediate electrodes "+" "-" are not illustrated for clarity's sake.

In the Figures 3, 4 and 5, reference 40 indicates an end body or head as a whole, preferably made from moulded thermoplastics, with stiffening ribs 41 and holes 42 for some tension rods, such as in the form of simple rods with threaded ends to be pulled as it will become apparent in the following; in alternative, said tension rods may be made from thermoplastic material, in particular being apt to withstand pull efforts, which may be welded or deformed on their ends, such as by hot deformation or vibrations, in order to pull the above heads and press the interlaid elements.

The head 40 integrates a set of inlet and outlet through-connectors for a fluid to be treated, such as water, in particular a first inlet 44, a first outlet 43, a second inlet 46 and a second outlet 45.

Substantially, the flat section of the head PP near the connector 46 is the resting base of the device 20; the connectors near this section PP, preferably the fluid inlets, are located in the lower section of the device, so as to have the outlets located in the upper section for favouring expulsion of the gas eventually formed inside the device.

Reference 47 indicates an electrode; for simplicity's sake, this is assumed to be the cathode previously indicated with 20C, which is incorporated in the head 40 and has an electric terminal indicated schematically with 47A.

Figures 6, 7, 8 and 9 are representing an end support element indicated with 50 in its whole, which is preferably made from a moulded elastic material (e.g. silicon or thermoplastic rubber).

As it will be noticed from Fig. 6, a first side 50 A of the support 50 has two first canalizations 51A and 51B, which branch out to second canalizations 52A e 52B, respectively; the second canalizations 52A and 52B branch out to further third canalizations 53A and 53B, respectively, which flow into an opening or main chamber 54

of the support 50 and a membrane C is provided for assembly in line with it as further described hereafter; the above first, second and third canalizations are substantially in the form of grooves delimited on the surface of the side 50A of the support 50.

The width of the third canalizations 53A and 53B is so restricted to avoid any sagging or flexing points of the membrane C near such locations; consequently, the number of said third canalizations is enough high to ensure a suitable passage for the fluid to be treated.

It should be noticed how the above first, second and third canalizations are open on the side 50A only of the support 50, leaving the opposite side 50B closed or blind.

The support 50 also comprises two passages sets 55A and 55B, delimited along opposite sides of the central opening 54, these passages 55A and 55B being isolated from the above first, second and third canalizations, in particular by means of sealing elements obtained in the body of the support 50.

As it can be noticed from Fig. 7, the side 50B of the support 50, on which a membrane C is going to rest, has a depressed seat SR with at least a sealing lip 56 extending all along the edge of the central opening 54; preferably, two concentric sealing lips 56 are provided, in order to increase the safety level should one of the two lips become defective.

The seat SR, provided for receiving the edges of the ion exchange membrane, has a preset depth being apt to compensate a portion (about a half) of the membrane thickness; however, the membrane can still be pressed between two adjacent supports for sealing purposes (as it will become apparent hereafter), without causing an excessive thickness that would compromise a total sealing of the device. In should be considered that for a number of thirty pairs of membranes, a likely deformation of a few tenths, such as due to the thickness of each membrane, causes a total deformation of several millimeters.

Moreover, the support 50 has outer peripheral lips indicated with 57A and 57B on its two opposite sides 50A and 50B, respectively, in order to ensure sealing to the outside, and is also provided with lips 58 surrounding the passages 55A and 55B.

The central opening 54 of the support 50 also houses a separation element not shown here, such as in the form of a braided wire net, being apt to keep in position the ion exchange membrane C assembled in line with the opening 54 spaced from the electrode 47 as further described hereafter, but letting a water flow go through.

Figures 10, 11, 12 and 13 are representing an intermediate support element indicated with 60 in its whole, preferably made from moulded elastic material (e.g. silicon or

thermoplastic rubber).

The intermediate support 60, for many aspects similar to the end support 50, has two first sets of channels 61A and 61B along two opposite sides of a respective central opening 62, and two second sets of channels 63A and 63B along the other two opposite sides of the central opening 62; the channels 63A and 63B are hydraulically connected to the same central opening 62 through small channels 64A and 64B; also in this case, also a respective separation element, such as a small wire net (not represented), is housed in line with the central opening 62, operating analogously to the previous one with reference to the support 50.

As it will be noticed from Fig. 11, the side 60B of the support 60 has at least a sealing lip 66 (preferably two sealing lips as for the support 50 are provided) extending all along the edge of the central opening 62; at least a similar lip indicated with 67 in Fig. 10 is also provided on the side 60A of the support 60; this lip 67, even if interrupted in some points due to the presence of the channels 64A and 64B, ensures anyway a counterthrust on the ion exchange membrane with respect to the continuous lip 56 of the adjacent support 50 (see Fig. 7), or with respect to the continuous lip 66 on the opposite side 60B of the adjacent intermediate support 60 (see Fig. 14), for sealing improvement on the ion exchange membranes C and A.

It should be noticed how respective lowered seats SR are also provided on the sides 60A and 60B of the support 60, having the lips 66 and 67, which extend around the central opening 54, for positioning the edges of the ion exchange membranes.

Moreover, the support 60 has outer peripheral lips 68 on the side 60A to ensure sealing to the outside, and lips 69 surrounding the set of channels 61A and 61B, in order to provide sealing between the channels themselves and the opening 62, channels 63A,64A and 63B, 64B as well as to the outside.

Both the support elements 50 and support elements 60 have peripheral through-holes FP appropriately located with respect to the holes 42 of the head 40.

Fig. 14 is representing as a partial exploded view a possible embodiment of a purification device 20 formed by the components of the previous Figures 3-13. In this example, as it will be noticed, a reduced number of supports 50, 60 and membranes A and C is provided for simplicity's sake of description; however, in practical actuation of the invention a larger number of these components will be provided (e.g. at least thirty airs of support element

pairs 60 with their relevant membranes C and A).

Both ends of the purification device 20 represented in Fig. 14 are formed by their respective heads 40, indicated with 40' and 40" in the figure. It should be noticed how both heads 40' and 40" are so arranged to have their respective surfaces bearing the electrodes 47 facing one another, since they are tilted by 180° with respect to each other.

Between the heads 40' and 40" are interposed the support elements 50 and 60, with their respective end supports 50' and 50" adjacent to each head; between the end supports 50' and 50" intermediate supports pairs indicated herein with 60' and 60" are located in turn.

As it will be noticed, the end supports 50' and 50" are so arranged to have their respective sides 50A, on which the canalizations 51A-51B, 52A-52B and 53A-53B are delimited, facing the surface of the respective head 40' and 40" bearing the electrode 47, both elements 50' and 50" being oriented by 90° to each other.

The intermediate support elements 60' and 60" are so arranged, on the contrary, to have the side 60A of the element 60' facing the side 50B of the element 50' adjacent to it, and the side 60B of the element 60" facing the side 50B of the element 50" adjacent to it, with the element 60' assembled in the same direction but rotated by 90° with respect to the element 60".

Between the support 50' and the support 60', as well as between the support 50" and the support 60" a membrane C is located in line with the seats SR of the relevant central openings 54 and 62; between the two adjacent supports 60' and 60" a membrane A is located in line with the seats SR of the relevant central openings 62.

The resulting assembly (also inclusive of the intermediate electrodes and net separators previously mentioned but not shown herein), is mounted and packed by means of tension rods (also not represented) or other elements apt to the purpose. These tension rods, as said, may consist e.g. of simple rods threaded on their ends for pulling, which go through the holes 42 of the heads 40' and 40" and the holes FP of the elements 50', 60', 60", 50"; a possible implementation may provide bands (metal or plastic bands), which surround the device 20 pressing said supports 50', 60', 60", 50" by means of both heads 40' and 40".

Thus, the edge of the membranes C interlaid between the lips 56 of the supports 50' and 50" and the lips 67 and 67 of the supports 60' and 60", whereas the edge of the membrane A interlaid between the lips 67 of the support 60" and lips 66 of the support 60'. In particular, this embodiment will minimize the portion or edge of membrane A or C

required for maintaining it in position, as well as obtaining the relevant hydraulic seal (the latter being obtained by means of the continuous lips 56 o 66, as the case may be).

As a result, following the above arrangement, various channels are formed in the device 20 of Fig. 14:

First Electrode Channel

The water delivered by a pump (analogous operation of the pump 31 of Fig. 1) to the inlet 46 of the head 40' reaches the central opening 54 of the support 50' through the first, second and third canalizations 51A, 52A e 53A of the latter (these canalizations are not visible in Fig. 14); the same water will then flow across the opening 54 in crosswise direction and across the third, second and first canalizations 53A, 52B and 51B of the same support 50' to reach the outlet 45 of the head 40'.

Second Electrode Channel

The water delivered by a pump (analogous operation of the pump 31 of Fig. 1) to the inlet 46 of the head 40" reaches the central opening 54 of the relevant support 50" through the first, second and third canalizations 51A, 52A e 53A (not visible); the same water will then flow across the opening 54 in crosswise direction and across the third, second and first canalizations 53A, 52B e 51B of the same support 50" and then reach the outlet 45 of the head 40".

Product Channel CP

The water delivered by a pump (analogous operation of the pump 12 of Fig. 1) to the inlet 44 of the head 40' reaches the channels 63B of the intermediate support element 60' through the passages 55B (not visible) of the relevant support 50'; from these channels 63C, the water will flow through relevant channels 64B to the central opening 62 of the same support 60' and across it; the water then reaches the channels 64A of the same support 60' and the channels 63A. From the channels 63A the water can then reach the outlet 43 of the head 40' through the passages 55B of the support.

It should be noticed how in the above example, the water can also reach the channels 61B and 61A of the support 60", which are anyway closed in the direction of the head 40" by the side 50B of the end support 50".

Should the device provide further intermediate support elements compared to the representation in Fig. 14, the channels 61B and 61A of the element 60" represented herein would be connected in series to the channels 63B and 63A of a further intermediate support

element 60 forming two manifolds, which supply in parallel the channels 64B of the various intermediate support elements of equal type and receive the outlet flow from the relevant channels 64A, respectively.

Concentrate Channel CC

The water delivered by a pump (analogous operation of the pump 15 of Fig. 1) to the inlet 44 of the head 40" reaches the channels 63B of the intermediate support element 60" through the passages 55A of the relevant support 50"; from said channels 63B, the water will flow through the relevant channels 64B to the central opening 62 of the same support 60' and across it; the water then reaches the channels 64A of the same support 60" and then the channels 63A. From these channels 63A the water can then reach the outlet 43 of the head 40" through the passages 55B of the support 50".

In the above example, the water can also reach the channels 61B and 61A of the support element 60', which are anyway closed in the direction of the head 40' by the side 50B of the end support 50'.

Also in this case, should the device provide further intermediate support elements compared to the representation of Fig. 14, the channels 61B and 61A of the element 60" would be connected in series to the channels 63B and 63A of a further intermediate support element 60 forming two manifolds, which supply in parallel the channels 64B of the various support elements of equal type and receive the outlet flow from the relevant channels 64A, respectively.

In the example of Fig. 14, the first and second Electrode channel are independent and interconnected outside the decalcifier 20 to a respective water circulation circuit. Obviously, these Electrode channels may be interconnected inside the decalcifier 20, such as by means of through-holes in the various supports 50 and 60; analogous configurations as provided for connecting the channels of the support may be utilized for obtaining this result.

In a non limiting application example, the decalcifier 20 of Fig. 14 so arranged to have the connectors 44 and 46 located in the lower section, whereas the connectors 43 and 45 are located in the upper section; this in view of favouring gas outflow (upwards) of the gases eventually forming in the cell during operation.

Following the above improvement, i.e. according to the mirror-like structure of the body of the heads 40, the decalcifier 20 will be preferably assembled in an angled position.

substantially in the form of a rhombus (i.e. one of the vertexes facing downwards), so as to have the inlets or outlets oriented downwards, though slightly angled between them.

Figures 15, 16 and 17 are illustrating a head 40 according to a possible implementation of the invention; in these figures the same numbers of the previous figures are used to indicate equivalent technical elements.

According to this implementation, the canalizations previously indicated with 51A-51B, 52A-52B and 53A-53B are obtained directly on the surface of the head 40, instead of the end support 50, the latter having a substantially flat surface on its side 50A. Moreover, this implementation provides small supports PS in line with the canalizations 52A-52B for improved mounting of the end support 50.

In the Figures 18, 19, 20 and 21 is illustrated an end support element 50 to be used paired to the head 40 of the Figures 15-17; also in these figures the same reference numbers of the previous figures are used to indicate equivalent technical elements.

In the support 50, in the area no longer occupied by the above first, second and third canalizations, small channels branches indicated with TC facing the canalizations 51A-51B, 52A-52B and 53A-53B now borne by the head 40 (see Fig. 17) are available, in order to allow or anyway favour a crosswise water flow between both the canalizations and the main chamber 54 of the support 50; also these channels TC will be open only on the side 50A of the support 50.

In the support 50 of the Figures 18-21, a separation net RD manufactured in one piece with the relevant support 50, as previously mentioned, is mounted in line with the main chamber 54; this embodiment allows a minor number of pieces (support 50 and net RD incorporated as one piece), with a lower cost of the part (one moulding cycle and storage of one part only required) and easier assembly operations.

According to the suggested implementation, in the support 50 each set of passages 55A and 55B as for the embodiment of Figures 6-7, is replaced by a sole relevant passage 55A, 55B of appropriate form and section.

In the Figures 22-25 is illustrated an intermediate support element 60 to be used paired to the head 40 of the Figures 15-17 and to the support 50 of the Figures 18-21: also in the Figures 22-25 the same reference numbers of the previous figures are used to indicate equivalent technical elements.

Also in the support 60 of the Figures 22-25, a separation net RD manufactured in one piece

with the relevant support 60 is mounted in line with the main chamber 62. Moreover, in the support 60 according to the suggested implementation, each set of passages 61A and 61B is replaced by one sole passage 61A, 61B; also the two sets of channels 63A and 63B are now replaced by relevant sole channels from which the channels 64A and 64B are departing.

It should be noticed how in the implementation of the Figures 22-25, provision of the sole channels 63A and 63B can be obtained because the single channels 64A and 64B of the intermediate support elements 60 have a closed lower portion operating as a joining element in the form of a thin lamina, between the various isles of material arising between said channels 64A and 64B; the presence of this thin material lamina represents a rest for the various membranes C and A for a suitable seal of the latter on the proper lip 56 or 66 of the opposite support element 50 or 60, such a lip 56 or 66 actually forming a continuous seal all along the perimeter of the opposite side of the membrane C or A.

To this regard it should be noticed how apart from the selected embodiment for the support elements 60, the ratio of the width and depth of the single channels 64A and 64B is preferably below 5:1 (e.g. width 1,5 mm and depth 0,3 mm), for instance comprised between about 2:1 and 3:1 (e.g., width 1,2-1,3 mm to depth 0,4-0,6 mm).

Fig. 26 illustrates an assembly example of a cell 20 comprising the components shown in the Figures 15-25.

For manufacturing both supports types 50 and 60 with the net RD as one integral part, all common processes apt to the purpose may be adopted, such as multipoint injection moulding, in particular, at least a peripheral and simultaneous central injection of thermoplastic material; by way of example, said central injection taking place either in line with or in proximity of some crossing or intersection points of the filaments or mashes of the net RD.

A non limiting implementation example of the net RD provides two sets of substantially semicircular filaments or with an arched profile to the membrane A or C, opposed to each other and solidly connected, e.g. as in a flat section, crossing together in a substantially diagonal or inclined direction with respect to the direction of the channel branches TC of the end supports 50 and/or channels 64A and 64B of the intermediate supports 60.

However, the moulding process should leave no burrs nor moulding scraps in the areas near the resting points of the membrane A or C on the net RD, in order to avoid possible mechanical damages (wear due to rubbing on the edges, cuts, etc.) to the membrane, in

particular when subject to the side thrusts of the water flowing in the cell.
Preferably, but not necessarily, the filaments section of the net RD should be rounded or have no sharp edges in the resting areas, in order to avoid possible damages to the membrane; in these manufacturing areas of the part thermoplastic or rubbery material injection points should be preferably avoided for preventing irregular surfaces due to a breakage or detachment of the feedhead (hardened reject part in the mould channels conveying the injected material to the various cavity points) or of the moulding nozzle from the moulded part.

The above arched section of the separation net RD is substantially resting with its tangential portion on the ion exchange membrane, minimizing the membrane area covered by the net, i.e. reducing the membrane area subject to a missed ionic exchange.

It should also be noticed how moulding the separation net RD in one integral part with the support will ensure an exact position (centring with respect to the central opening 62 or 54) and thickness, for the membrane to always have a good rest in all its points, also when subject to hydraulic flow.

Substantially, the thickness of the separation net RD equals the distance between the two depressed housing seats SR of the membrane of the support 60, i.e. a thickness equalling the distance between two adjacent membranes or between a membrane and an adjacent electrode.

Preferably, the division net RD is made from the same elastic material used for the support, to avoid that likely light dimensional tolerances (such as excessive thickness) or rests of the moulding process (flashes) may damage the membrane, which is continuously subject to micro-movements by the hydraulic flow (in particular, when this flow is a high one for improving the performance of the device, as in a preferential operating configuration for the purposes of the invention).

In a further implementation, the net RD may be in a different material from the support 50 or 60 even if made integral to the latter, i.e. manufactured separately and welded to the relevant support, or co-moulded to the support injecting the two materials at different stages of one same moulding cycle; thus, an integral part will be obtained, for easy handling during assembly of the device 20.

In Fig. 27 an exploded view is representing a possible embodiment of a support 60 according to the implementation of the Figures 23-25, which is either co-moulded or over-

moulded, or anyway integral with an intermediate electrode "+" o "-", indicated herein with 70; also in this figure the same reference numbers of the previous figures are used for indicating equivalent technical elements.

In the example shown in Fig. 27, the intermediate electrode 70 is made from electric conductive plastic or other electric conductive material suitable for the purpose, and may have been previously moulded and/or formed separately for its over-moulding with another isolating material, such as an elastic material (e.g. silicon or thermoplastic rubber or analogous materials), for obtaining the support 60.

For simplicity's sake, only the intermediate support 60 comprising the intermediate electrode 70 is illustrated herein, assuming that the relevant end support 50 has no intermediate electrode "+" or "-" (at any rate the support 50 may be manufactured analogously to the description of the support 60 of Fig. 27, i.e. comprising a similar intermediate electrode); as previously mentioned, in this configuration at least one of the main end electrodes (20B or 20C of Fig. 2) utilized for decalcification, appropriately electrically switched and paired to the intermediate electrodes "+" and "-", is used for electrochemical self-cleaning.

As it will be noticed from Fig. 28, the intermediate electrode 70 comprises a first element 71 in the form of a curved rod, which operates both as an electric connecting element and mechanical fastening element respect to the support 60; a second element 72, also in the form of a small rod, mainly operates as a fastening element of the electrode 70 on the opposite end of the central opening 62 of the support 60.

The small rod 71 ha a contacting ring 73, being apt to receive a relevant connecting rod or manifold by interference, one of them indicated with BC in the subsequent Fig. 29; this connecting rod BC is preferably made from metal or has a metal core, in order to obtain a low electric resistance and good current distribution all over its length. Moreover, this rod BC should have a sturdy structure for insertion by interference in a plurality (e.g. 30) of contacting rings 73; the latter are preferably made from plastic or conductive rubber for penetration by interference, but ensuring a subsequent electric contact, such as elastic type. The rings 73 may also be partially metallic (provided they are isolated from the liquid to be treated), such as fitted with inner blades for radial contact on the small rod BC.

The rods 71 and 72 of the electrode 70 have preferably a minor thickness than the support 60 (with reference to the resting side of the membranes, which is the thinnest section), in

order to be fully coated or over-moulded by the material of the support itself, i.e. making the electrode 70 integral with the support; thin relieves 74, 75 and 76 of the same thickness of the matching area of the support 60 are preferable on the rods 71 and 72 for maintaining the latter centred in the mould during over-moulding operations. In this case, the rods 71 and 72 are nearly completely coated with the electric isolating material of the support 60, just letting the above relieves 74, 75, 76 emerge, which are anyway located in a predetermined area causing no problems for the operation of the device 20.

The electrode 71 also has a net extending between the rods 71 and 72, formed by a diagonal crossing of first filaments 77 and second filaments 78, facing out and being apt to maintain a first membrane A or C and a second membrane C or A in position, respectively; in the above example, the filaments 77 and 78 are made from electric conductive plastic or rubber, forming an integral part with the conductive rods 71 and 72.

In a possible embodiment, the first filaments 77 are made from electric conductive material (e.g. carbon fibre), whereas the second filaments 78 are made from isolating material (e.g. thermoplastic wire), so as to have an electric isolating net side and an electric conductive net side. Thus, the electric conductive material will not produce an electric bridge in the net thickness (between the two membranes), short-circuiting the current flow to be circulated in the solution to be treated.

According to this implementation, the distribution and/or form of the filaments may differ from the one previously described, in order to connect all single electric conductive filaments to each other and/or to the rod 71.

At any rate, the filaments 77 and 78 are so arranged to let the liquid to be treated inside flow substantially parallel and/or in an angled direction to the surfaces facing out on the membranes, or simply flow in its thickness.

In Fig. 29 is illustrated an assembly example of a cell 20 comprising the components of the Figures 15-21 and 27-28. To this purpose, it is highlighted that the supports 50, 60 and the heads 40 have appropriate holes to let the rods BC spread totally or nearly totally across the cell, independently from the position or angle of the supports; the various supports in line with said holes and the holes FP, may have respective sealing lips.

In an embodiment example, a first rod BC runs across a first support 60 contacting electrically a first ring 73, then it runs across a second support 60 (rotated by 90° with respect to the first one) without performing any electric connections, and then it will run

across a third support 60 where a third ring 73 is electrically contacted. Always according to this embodiment example, a second rod BC runs across the first support 60 without performing electric connections, then it runs across the second support 60 contacting electrically a second ring 73, and then it will run across the third support 60 without performing any electric connections, and so on.

Thus, the two rods BC will easily perform an alternated electric connection of electrodes 70, obtaining the said polarity alternance.

In a further possible embodiment, the intermediate electrodes "+" and "-" can be realised in the form of a layer on one side of a relevant ion exchange membrane A or C. These intermediate electrodes may be obtained e.g. from a carbon fibre tissue or porous sheet of electric conductive plastic material (e.g. porous structure such as GoreTex®).

Thus, an "electrode/membrane" is provided, consisting of a single sheet with the ion exchange membrane on one side and the above electrode on the other side, which being porous will not interfere with the ions circulation across the ion exchange membrane. Obviously, the use of two separate sheets may be provided as a further implementation, which are assembled together in the purification device 20 to form a structure similar to the one mentioned above.

In the Figures 30, 31, 32 and 33 a possible embodiment of a support 60 is represented in an exploded view, to be paired to the above "electrode/membrane" for use.

The support 60 of the Figures 30-33, substantially similar to the one of the Figures 21-25, is co-moulded or over-moulded or anyway integral with one or more contacting rods 80; in the above example, each support 60 integrates two rods 80, represented in the Fig. 32 in an exploded view with respect to the support.

The rods 80 practically have a form similar to the rod 71 of Fig. 28, with relevant contacting ring 83 and can be made from electric conductive plastic or other suitable material; the rods 80 can be moulded separately and then over-moulded with elastic material (e.g. silicone or thermoplastic rubber or analogous materials) in order to obtain the supports 60. Also the rods 80 can be fitted with relieves, one of them indicated with reference 85, operating as the ones previously indicated with 74, 75 and 76 in Fig. 28.

In the example represented in the Figures 30-32, the rods 80 are arranged along the opposite sides of the main chamber of the support 60, in order to electrically contact the electrodes/membrane.

Fig. 33 is representing a cell manufactured using the supports 60 of the Figures 30-32, also indicated in this case with 60' and 60" and the above electrodes/membrane EC (those having a cationic membrane portion) and EA (those having an anionic membrane portion). As mentioned, in the non limiting example of Fig. 30 two opposite pairs of contacting rods 80 are provide, which will be connected together with the same polarity by means of rods BC outside the device 20; thus, both the reliability (double inner contact on the membrane) and/or distribution of the electric current flows in the electric conductive plastic materials having a higher electric resistance are improved; however, nothing will hinder the use of one contacting rod 80 alone for each support 60' or 60".

As to the device 20, the electrodes/membrane EC and EA are always assembled oriented in the same direction, so as to form an electrode-membrane (anionic) and electrode-membrane (cationic) alternance, and so on.

The membrane surface of the electrode/membrane EC and EA will be assembled for support and sealing on the side 60B of the support fitted with the continuous sealing lips 66 all over the inner perimeter; the electrode surface of the electrode/membrane EC and EA, on the contrary, will be assembled for support on the contacting rods 80 on the side 60A of the support fitted with the channels 64A and 64B for the liquid flow.

From the above description the features and advantages of the present invention are clear, among which the following features should be highlighted:

- provision of a cell or electrochemical device 20 for liquids purification incorporating such features being apt to improve its operating and life performance, as well as simplify its manufacture and reduce costs; if required, the device may have smaller dimensions for its easy assembly inside household appliances;
- provision of an inner automatic cleaning or washing system in the device 20, this system being in particular apt to produce at least a cleaning substance directly from the liquid being treated (in the example an acid substance, but in another embodiment could be a basic substance); the self-cleaning system described above comprises a plurality of intermediate electrodes, being apt to produce the substance to be used for the inner washing of the electrochemical device;
- intermediate electrodes are made from low cost material and/or directly incorporated on the ion exchange membranes of the device, ensuring easy electric interconnection;
- the opportunity of providing a large number of pairs of cationic membranes C and

anionic membranes A, in particular for containing the size of the decalcification electrodes 20B and 20C (or 47), as well as to limit the dimensions and cost of the whole device;

- the special sealing configuration on the ion exchange membranes C and A, based on the use of the lips 56, 66 and 67 of the supports 50 and 60, being apt to reduce to a maximum extent the membrane surface utilized as a sealing edge, which does not come in contact with the water and does not take part at the ionic exchange, though levying on the manufacturing cost of the decalcifier (in the instance described by way of example of the present invention, the unused edge portion of the membranes A and C all over the perimeter is only about 5 mm all around);
- the special sealing configuration on the ion exchange membranes C and A also providing the use of supports fitted with a plurality of very narrow channels 64A and 6AB for avoiding possible flexures of the ion exchange membranes with a consequent sealing performance loss on the opposite lips 56, 66;
- the special configuration of the canalizations 51A,51B, 52A,52B, 53A,53B, preferably obtained on the heads 40, ensuring a total and even distribution of the liquid on the end electrode 20B or 20C or 47, also with high flow-rates, i.e. reducing the risk of deposits;
- the use of the canalizations 51A,51B, 52A,52B, 53A,53B obtained on the heads 40 permits to reduce the risk of flexure of the end supports 50, if required, avoiding a consequent reduction of the relevant sections and flow-rates;
- standardisation and reduction of the number of parts required for manufacturing the purification device through a set of equal elements that can be assembled with different angulations or directions for various purposes (one sole head and intermediate support elements);
- easy assembly by means of automatic systems due to the reduced number of different parts and wide mechanical tolerances of the parts;
- nearly total use of components made from moulded thermoplastic material, i.e. highly economical;
- the global configuration of the device body, which in spite of its manufacturing symmetric elements is apt to be located for ensuring an easy outflow of the gases eventually formed.

The present invention has been described with reference to its application for water

purification in the field of household appliances, but it is also capable of application in other fields, such as in the industrial sector, e.g. for milk, wine, beverages and food treatment, and so on, and for application in household water purification systems to be installed e.g. under a wash-basin.

The hydraulic configuration of the device 20 applied in the industrial field may obviously change from the previous example, and eventually comprise ion exchange membranes of different type, such as bipolar membranes alternating anionic and cationic membranes or providing vents for the gases eventually formed in the device during operation.

In a possible implementation, manufacture of the device 20 may also make use of different membranes, such as alternating bivalent cationic membranes with univalent cationic membranes (which do not let Calcium and Magnesium go through, being bivalent ions).

Configuration of such a device 20 would be substantially similar to the devices described above with reference to the use of cationic and anionic membranes, obtaining Concentrate channels in which the substances will collect (since they are refused by the univalent membrane).

Other possible embodiments of the invention may derive from the combination of at least a portion of the various systems or components previously described by way of non limiting example.

* * * * * * * * * * *

CLAIMS

1. Arrangement for electrochemical purification and/or treatment of a liquid, comprising at least two first electrodes (20B,20C), between which are located at least:

- a first type ion exchange separator element (C;EC);
- a second type ion exchange separator element (A;EA);
- a plurality of channels (CE,CC,CP) between said first electrodes (20B,20C), each channel (CE,CC,CP) being at least partially delimited by at least a ion exchange separator element (C,A;EC,EA);

where a first portion of liquid conveyed at least in one (CP,CE) of said channels apt to yield ions in order to be purified when an electric current flow is applied between said first electrodes (20B,20C), and a second portion of liquid conveyed at least in another (CE,CC) of said channels, apt to receive the ions yielded by said first portion of liquid when said electric current flow is applied,

characterized in that it provides cleaning means (+,-) for producing a cleaning substance or solution apt to dissolve and/or remove deposits or scaling, in particular saline precipitates or bio-films eventually formed inside at least one of said channels (CE,CC, CP).

2. Arrangement according to claim 1, characterized in that said cleaning means comprise a plurality of second electrodes (+,-), located in line with at least a few of said channels (CE,CC,CP).

3. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are electrically connected to pairs with alternated polarities, connected in parallel to each other, so as to form an alternance of positive and negative polarities.

4. Arrangement according to claim 2 or 3, characterized in that it provides controlling means, capable of electric supply to said second electrodes (+,-).

5. Arrangement according to claim 4, characterized in that said second electrodes (+,-) are operative when a current flow is applied between them for producing said cleaning substance or solution from the liquid itself present at least in a few of said channels (CE,CC,CP).

6. Arrangement according to claim 4, characterized in that said controlling means are capable of electric supply at different times to said first electrodes (20B,20C) and said second electrodes (+,-).

7. Arrangement according to claim 5, characterized in that it provides means for

maintaining the liquid in static conditions at least in one of said channels (CE,CC.CP) and the liquid in dynamic or circulating conditions at least in another of said channels (CE,CC,CP) during application of the current flow between said second electrodes (+,-).

8. Arrangement according to claim 4, characterized in that said controlling means are capable of inverting the polarity of said second electrodes (+,-).

9. Arrangement according to the previous claim, characterized in that said controlling means operate for performing a first supply cycle to said second electrodes (+,-) with a first polarity, in order to produce said washing substance or solution at least in one of said channels and a second supply cycle to said second electrodes (+,-), with an opposed polarity to the previous one, in order to produce said washing substance or solution at least in another of said channels.

10. Arrangement according to the previous claim, characterized in that said controlling means operate for storing information related to at least said first and/or second cycle.

11. Arrangement according to claim 4, characterized in that said controlling means are programmed for activating a current flow between said second electrodes (+,-) as a function of measurements performed by sensing means.

12. Arrangement according to the previous claim, characterized in that said sensing means comprise one or more flow or flow-rate sensors.

13. Arrangement according to claim 11, characterized in that said sensing means comprise at least an electric absorption meter.

14. Arrangement according to claim 1, characterized in that it provides at least a first and second channel (CE,CC) for said second portion of liquid and at least a third channel (CP) for said first portion of liquid, said third channel (CP) being interlaid between a respective first and second channel (CE,CC).

15. Arrangement according to the previous claim, characterized in that:

- said third channel (CP) is at least partially delimited by a first type separator element (C;EC) and a second type separator element (A;EA),
- each one of said first and second channel (CE,CC) is at least partially delimited by a first type separator element (C;EC) and a second type separator element (A;EA) or by one of said first electrodes (20B,20C) and one of said separator elements (C,A;EC,EA).

16. Arrangement according to claim14 or 15, characterized in that it provides at

least two of said third channels (CP), between which an intermediate channel is delimited (CC), the latter being at least partially delimited on one side by a first type separator element (C;EC) delimiting one of said third channels (CP) and on the other side by a second type separator element (A;EA) delimiting the other of said third channels (CP).

17. Arrangement according to at least one of the previous claims, characterized in that it provides circulating or recirculation means (12,22,23,15,21,24) for producing a substantially closed circuit and/or continuous circulation of said first portion of liquid between collecting means (P,S) and their relevant channel or channels (CE,CC,CP), until a preset purification value of said liquid is reached.

18. Arrangement according to at least one of the previous claims, characterized in that it provides first collecting means (P) of said first portion of liquid.

19. Arrangement according to at least one of the previous claims, characterized in that it provides second collecting means (S) of said second portion of liquid.

20. Arrangement according to claim 4, characterized in that said controlling means operate for inverting the polarity of said first electrodes (20B,20C).

21. Arrangement according to the previous claim, characterized in that it provides means for inverting the operations of said first collecting means (P) and said second collecting means (S), so that said first collecting means (P) will collect said second portion of liquid and said second collecting means (S) will collect said first portion of liquid, with recirculation to their relevant channels (CE,CC,CP).

22. Arrangement according to at least one of the previous claims, characterized in that it provides a circulation or recycle circuit (30A,30B,31-34) for a washing solution or liquid of said first electrodes (20B,20C) and/or their relevant channels (CE).

23. Arrangement according to the previous claim, characterized in that the channels (CE) related to said first electrodes (20B,20C) are hydraulically connected to each other.

24. Arrangement according to the previous claim, characterized in that the separator elements (C,A;EC,EA) delimiting the channels (CE) related to said first electrodes (20B,20C) are of equal type.

25. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are made from a selected material of the range comprising electric conductive synthetic materials or of the range comprising conductive material fibres.

26. Arrangement according to claim 2, characterized in that said second electrodes

(+,-) are made from a material having a higher electric resistance than the resistance of the liquid.

27. Arrangement according to claim 1 or 2, characterized in that it provides means for hindering electric short-circuits between two adjacent separator elements (C,A;EC,EA).

28. Arrangement according to claim 2, characterized in that said second electrodes (+,-) have in their own thickness a higher electric resistance than the resistance of the liquid.

29. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are made from a material with electric features being apt to obtain at least in one direction a higher electric resistance than the resistance of the liquid.

30. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are substantially in the form of a net.

31. Arrangement according to claim 2, characterized in that said second electrodes (+,-) have at least partially a porous or permeable structure.

32. Arrangement according to claim 2, characterized in that said second electrodes (+,-) operate at least partially as a spacer for a relevant separator element (C,A;EC,EA).

33. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are at least partially a composite structure.

34. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are paired to or a portion of a relevant separator element (C,A;EC,EA).

35. Arrangement according to claim 2, characterized in that said second electrodes (+,-) are solidly connected or paired to a relevant support element (50,60;50',50",60',60") of a separator element (C,A;EC,EA).

36. Arrangement according to at least one of the previous claims, characterized in that said intermediate electrodes (+,-) are interconnected and/or connected at least through a relevant electrically conductive element (BC), in particular in the form of a common contacting rod (BC).

37. Arrangement according to claim 1, characterized in that it provides two end bodies (40;40',40"), between them are provided supporting means (50,60;50',50",60',60") of said separator elements (C,A;EC,EA) and/or said second electrodes (+,-).

38. Arrangement according to the previous claim, characterized in that said end bodies (40) have each one a plurality of liquid inlet and outlet connectors (43-46).

39. Arrangement according to the previous claim, characterized in that said connectors (43-46) comprise at least an inlet (44,46) and outlet (43,45).

40. Arrangement according to the previous claim, characterized in that at least one of said end bodies (40) comprises at least a first inlet (44), a first outlet (43), a second inlet (46) and a second outlet (45).

41. Arrangement according to previous 37, characterized in that each end body (40) incorporates a relevant first electrode (47;20B,20C).

42. Arrangement according to previous 37, characterized in that said supporting means comprise a plurality of support elements (50,60;50',50",60',60"), each one of them delimiting a plurality of through-openings (54,55A,55B,61A,61B,63A,63B) for the liquid to flow through.

43. Arrangement according to the previous claim, characterized in that said through-openings (54,55A,55B,61A,61B,62,63A,63B) comprise a first opening (54,62), with one of said separator elements (C,A;EC,EA) assembled in line with it.

44. Arrangement according to the claims 42 and 43, characterized in that said through-openings (54,55A,55B,61A,61B,62,63A,63B) comprise at least a pair of second through-openings (55A,55B,61A,61B).

45. Arrangement according to the previous claim, characterized in that said through-openings (61A,61B,62,63A,63B) comprise at least a pair of third through-openings (63A,63B).

46. Arrangement according to the claims 40 and 45, characterized in that said second through-openings (55A,55B,61A,61B,62,63A,63B) of a second type support element (60;60',60") are in hydraulic communication with both the third through- openings (55A,55B,61A,61B,62,63A,63B) of another second type support element (60;60',60") and with said first inlet (44) and first outlet (43).

47. Arrangement according to the claim 45, characterized in that said third through-openings (63A,63B) are delimited in said second type support elements (60;60',60") and are in hydraulic communication with the relevant first opening (62) of the latter through small ducts (64A,64B) in the form of grooves delimited on one surface of the second type support element (60;60',60").

48. Arrangement according to the previous claim, characterized in that the width to depth ratio of said small ducts (64A,64B) is smaller than 5:1, in particular from 2:1 to 3:1.

49. Arrangement according to the claim 37 or 42, characterized in that said supporting means or elements (50,60;50',50",60',60") comprise at least two first type support elements (50;50',50"), each one cooperating with a relevant end body (40;40',40").

50. Arrangement according to the previous claim, characterized in that said supporting means (50,60;50',50",60',60") comprise one or more second type support elements (60;60',60"), each one cooperating with a respective first type support element (50;50',50") or another second type support element (60;60',60").

51. Arrangement according to claim 49, characterized in that at least one of said end bodies (40;40',40") and first type supports (50;50',50") have one or more channels on one surface (51A,51B,52A,52B,53A,53B) in the form of grooves.

52. Arrangement according to the previous claim, characterized in that said channels comprise one or several first channels (51A,51B) branching into respective second channels (52A,52B), the second channels (52A,52B) branching into further third channels (53A,53B).

53. Arrangement according to the claims 40 and 51 or 52, characterized in that said channels (51A,51B,52A,52B,53A,53B) are in hydraulic communication with said second inlet (46) and second outlet (45).

54. Arrangement according to the claims 43 and 51 or 52, characterized in that said channels (51A,51B,52A,52B,53A,53B) are delimited in said end bodies (40;40',40") and said first type support element (50;50',50") delimits some grooves (TC) on its surface facing said channels (51A,51B,52A,52B,53A, 53B), said grooves (TC) flowing into said central opening (54).

55. Arrangement according to the claim 43, characterized in that at least on one surface of said support elements (50,60;50',50",60',60") a depressed seat (SR) is delimited, which surrounds said first opening (54,62) and houses a portion or edge of a relevant separator element (C,A;EC,EA), in particular, the depth of said seat (SR) being equalling about a half of the thickness of said separator element.

56. Arrangement according to the claim 37, characterized in that at least on one surface of said support elements (50,60;50',50",60',60") a first sealing lip (56,62,67) is delimited in contact with a respective separator element (C,A;EC,EA), said first lip extending in particular around said first opening (54,62).

57. Arrangement according to the claims 55 and 56, characterized in that said first

sealing lip (56,62,67) is delimited in the range of said seat (SR).

58. Arrangement according to the claims 55 and 56, characterized in that at least said first sealing lip (56,62,67) and/or said seat (SR) are delimited on both the surfaces of said support elements (50,60;50',50",60',60").

59. Arrangement according to claim 37, characterized in that at least on a surface of said support elements (50,60;50',50",60',60") at least a second sealing lip (57A,57B,68) is delimited, inside the perimeter of which said openings are delimited (54,55A,55B,61A,61B,62,63A,63B).

60. Arrangement according to claim 37, characterized in that at least on a surface of said support elements (50,60;50',50",60',60") at least a third sealing lip (58,69) is delimited, inside the perimeter of which said second and/or third openings (55A,55B,61A,61B) are delimited.

61. Arrangement according to claim 43, characterized in that a relevant spacer means (RD) is positioned in line with said first opening (54,62), being apt to provide a gap between two adjacent separator elements (A,C;EA,EC).

62. Arrangement according to the previous claim, characterized in that said spacer means (RD) is substantially in the form of a net, comprises two crossed sets of filaments with a partially arched section.

63. Arrangement according to claim 51, characterized in that one or more supports (PS) are delimited in the frame of at least one of said channels (51A,52A,51B,52B).

64. Arrangement according to at least one of the previous claims, characterized in that said intermediate electrodes (+,-) comprise each one at least a contacting ring (73) being apt to receive and/or interconnect with a common contacting rod (BC).

65. Arrangement according to at least one of the previous claims, characterized in that said intermediate electrodes (+,-) comprise each one at least two small rods (80), each one arranged along two sides of said first opening (54,62).

66. Arrangement according to at least one of the previous claims, characterized in that said second intermediate electrodes (+,-) are incorporated in relevant support elements (50,60;50',50",60',60"), said second electrodes (+,-) having a thickness at least partially smaller than the thickness of the relevant support elements.

67. Arrangement according to claim 30, characterized in that said second electrodes (+,-) comprise first filaments (77) made from electrically conductive material and second

filaments (78) made from isolating material.

68. Arrangement according to claim 30 or 67, characterized in that said second electrodes (+,-) comprise filaments with at least a partially arched or circular section.

69. Arrangement according to claim 2 or 34, characterized in that said intermediate electrodes (+,-) comprise a layer or sheet of electrically conductive material placed on one side of a relevant separator element (A,C;EA,EC).

70. Arrangement according to the previous claim, characterized in that the units (EC,EA) formed each one by an intermediate electrode (+,-) and a separator element (A,C;EA,EC) are oriented in the same direction.

71. Arrangement according to at least one of the previous claims, characterized in that said separator elements are in the form of ion exchange membranes (A,C;EA,EC).

72. Arrangement according to the previous claim, characterized in that said separator elements (A,C;EA,EC) are selected from one or more of the following groups or types: anionic membranes and/or cationic membranes and/or bipolar membranes.

73. Arrangement according to claim 71, characterized in that said separator elements (A,C;EA,EC) comprise at least pairs or sets of the following types:

- anionic membranes and cationic membranes, either bivalent or univalent,
- univalent cationic membranes and bivalent cationic membranes,
- univalent anionic membranes and bivalent anionic membranes.

74. Arrangement according to at least one of the previous claims, characterized in that it provides means for evacuating said substance or solution from said channel or channels (CE,CC,CP), along with likely deposits or scaling dissolved or removed by it.

75. Arrangement according to at least one of the previous claims, characterized in that it provides means for washing or flushing said channel or channels (CE,CC,CP), in order to eliminate said substance or solution from the latter and the likely deposits or scaling that have been dissolved or removed.

76. A purification method or electrochemical treatment of a liquid, based on the use of

- at least two electrodes (20B,20C) between which are at least:
- a first type ion exchange separator element (C;EC);
- a second type ion exchange separator element (A;EA);
- a plurality of channels (CE,CC,CP) between said first electrodes (20B,20C), each

channel (CE,CC,CP) being at least partially delimited by means of at least a ion exchange separator element (C,A;EC,EA);

where a first portion of liquid is conveyed at least in one (CP,CE) of said channels and a second portion of liquid is conveyed at least in another (CE,CC) of said channels, with said first portion of liquid yielding ions to said second portion of liquid when an electric current flow is applied between said first electrodes (20B,20C), characterized in that it provides the production of a cleaning substance or solution, being apt to dissolve and/or remove any deposits or scaling eventually formed at least inside one of said channels (CE,CC, CP).

77. A method according to claim 76, characterized in that said substance or solution is produced by the liquid present at least in one of said channels (CE,CC,CP).

78. A method according to claim 76 or 77, characterized in that said substance or solution is formed following an application cycle of electric current between said first electrodes (20B,20C).

79. A method according to at least one of the previous claims, characterized in that said substance or solution is an acid substance or solution.

80. A method according to at least one of the previous claims, characterized in that said substance or solution is a basic substance or solution.

81. A method according to claim 76 or 77, characterized in that with the production of said substance or solution, in particular an acid solution, simultaneous production of an opposite type solution is provided, in particular a basic solution.

82. A method according to claim 76 or 77, characterized in that said substance or solution is produced generating an electric field or electric voltage or electric current flow between pairs of second electrodes with alternated polarities (+,-), said second electrodes (+,-) being in line with at least a few said channels (CE,CC,CP).

83. A method according to the previous claim, characterized in that during application of electric current between said second electrodes (+,-), the liquid is maintained in static conditions at least in one of said channels (CE,CC,CP), i.e. without hydraulic circulation.

84. A method according to claim 82 or 83, characterized in that during application of electric current between said second electrodes (+,-), the liquid is in dynamic conditions at least in one of said channels (CE,CC,CP), i.e. with hydraulic recirculation.

85. A method according to claim 76, characterized in that it provides continuous

circulation of the liquid in said channels (CE,CC,CP) during application of electric current between said first electrodes (20B,20C), until a preset treatment or purification value of said liquid is reached.

86. A method according to the previous claim, characterized in that said continuous circulation occurs between liquid collecting means (P,S,34) and relevant channels (CE,CC,CP).

87. A method according to claim 76, characterized in that it provides dosage and collection of said first portion of liquid at least in a first container (P).

88. A method according to claim 76, characterized in that it provides dosage and collection of said second portion of liquid at least in a second container (S).

89. A method according to claim 76, characterized in that it provides periodic polarity inversion of said first electrodes (20B,20C).

90. A method according to claim 76, characterized in that it provides dosage and collection of a third portion of liquid at least in a third container (34).

91. A method according to claims 87-89, characterized in that it provides inversion of the operations at least of said first and second containers (P,S), and/or relevant hydraulic circuit, to have said second portion of liquid collected and circulated in said first container (P) and said first portion of liquid collected and circulated in said second container (S).

92. A method according to the previous claim, characterized in that it provides storage of information related to the last polarity used for said first electrodes (20B,20C).

93. A method according to claim 76, characterized in that it provides a first cleaning cycle with said substance or solution at least of a first channel and a second cleaning cycle with said substance or solution at least of a second channel.

94. A method according to the previous claim, characterized in that said first and second cleaning cycles are performed each one after a relevant application of electric current between said first electrodes (20B,20C).

95. A method according to claim 82, characterized in that application of electric current between said second electrodes (+,-) is controlled in function of the measurements performed by sensing means.

96. A method according to claim 76 or 95, characterized in that it provides for measurement of the liquid flow-rate in one or more channels (CE,CC,CP), in particular by means of a flow meter.

97. A method according to claim 76 or 95, characterized in that it provides for measurement of the electric absorption during application of the electric current between said first electrodes (20B,20C).

98. A method according to at least one of the previous claims, characterized in that it provides at least a flushing step of said channel or channels (CE,CC,CP), in particular after a cleaning cycle of the latter executed with said substance or solution.

99. A method according to at least one of the previous claims, characterized in that it provides at least a flushing step of said channel or channels (CE,CC,CP) for removing said cleaning substance or solution from said channel or channels (CE,CC,CP), along with the likely deposits or scaling that have been dissolved or removed by it.

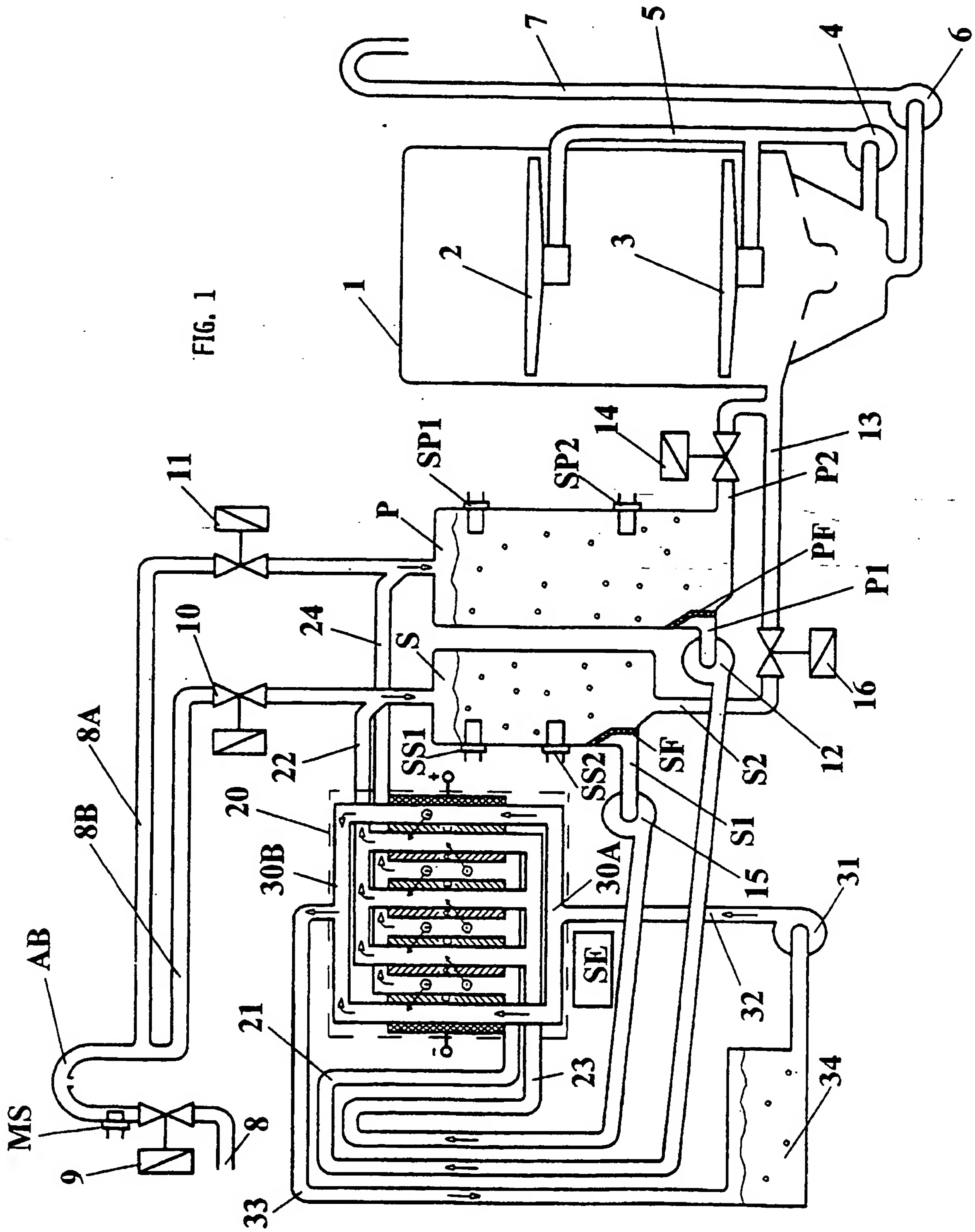
100. A household apparatus, in particular a washing machine, comprising a purification arrangement or treatment according to one or more of the claims 1 to 75.

101. A household apparatus, according to the previous claim, characterized in that said arrangement provides water softening or decalcification.

101. A household apparatus, according to claim 100, characterized in that said arrangement provides purification and/or recovery of the water already utilized for washing purposes.

102. A household apparatus, according at least to one of the previous claims, characterized in that said arrangement is controlled at least partially by the control system of the apparatus itself.

103. A household apparatus, in particular a washing machine, which uses the purification method or treatment according to one or more of the claims 76 to 99, in particular for water purification or softening.


1
2
3
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6
7
8
8A
8B
9
10
11
12
13
14
15
16
20
21
22
23
24
30A
30B
31
32
33
34
AB
MS
P
P1
P2
PF
S
S1
S2
SF
SE
SP1
SP2
SS1
SS2

FIG. 1

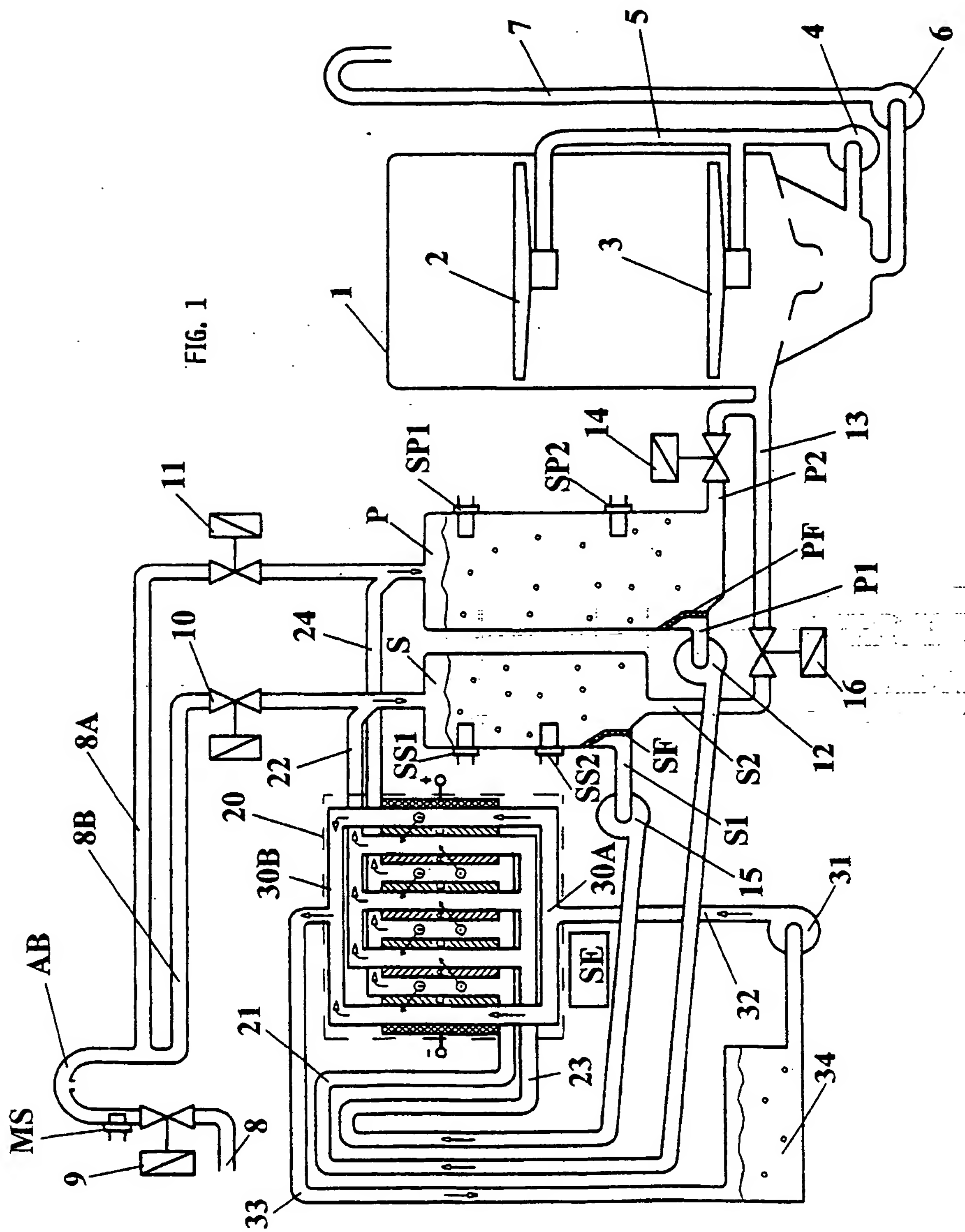

1
2
3
4
5
6
7
8
8A
8B
9
10
11
12
13
14
15
16
20
21
22
23
24
30A
30B
31
32
33
34
AB
MS
P
P1
P2
PF
S
S1
S2
SF
SP1
SP2
SS1
SS2
SE

FIG. 1

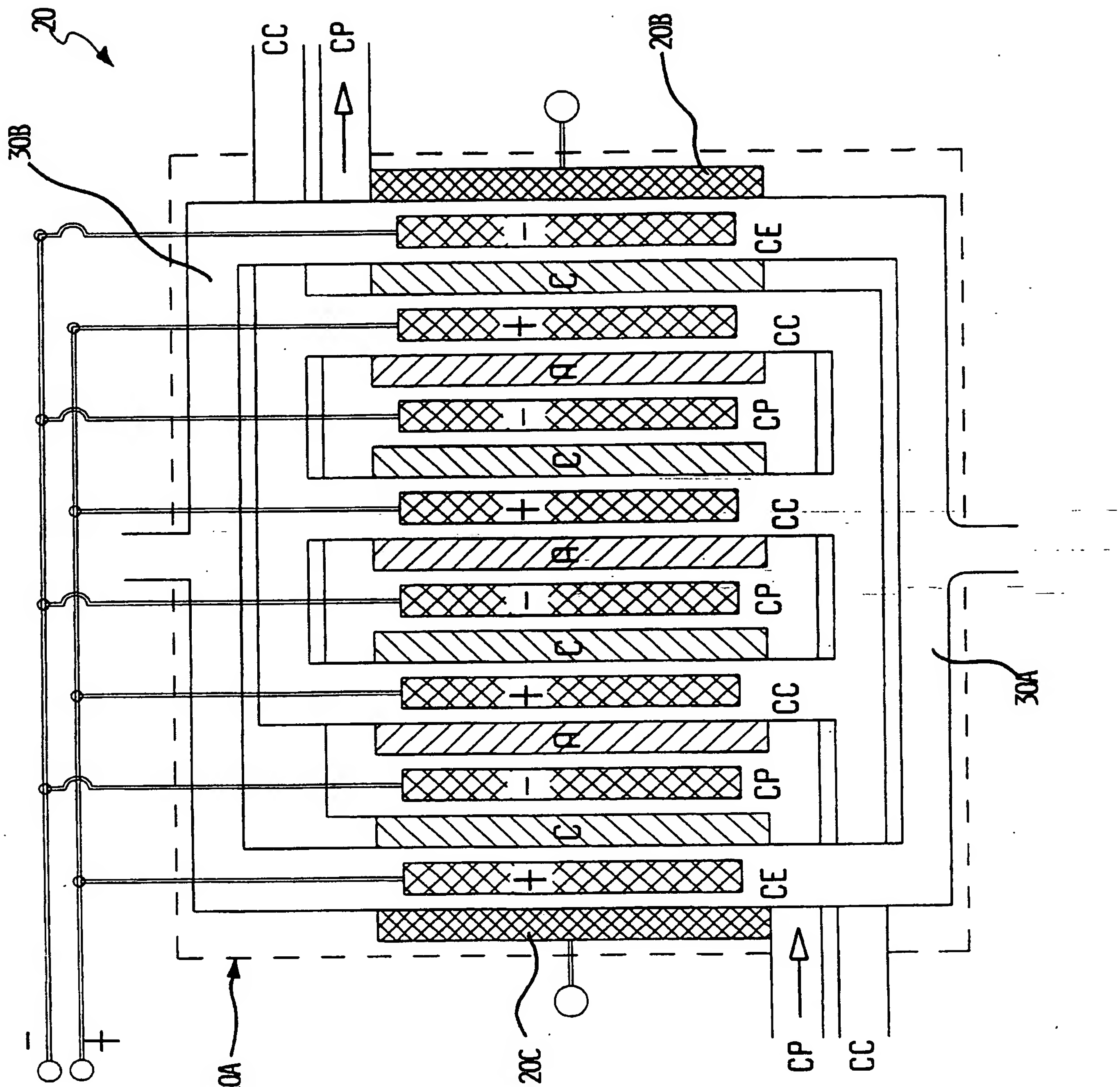


FIG. 2

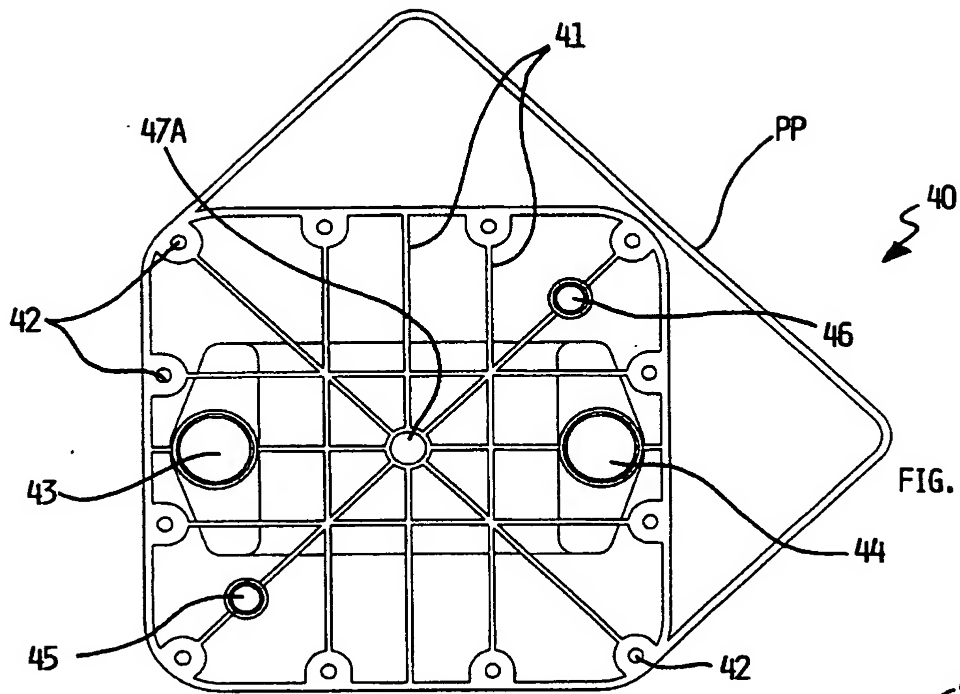


FIG. 3

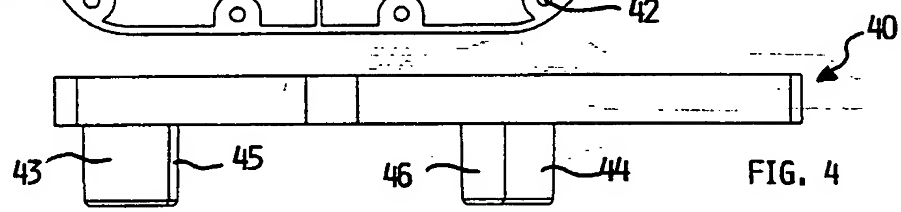


FIG. 4

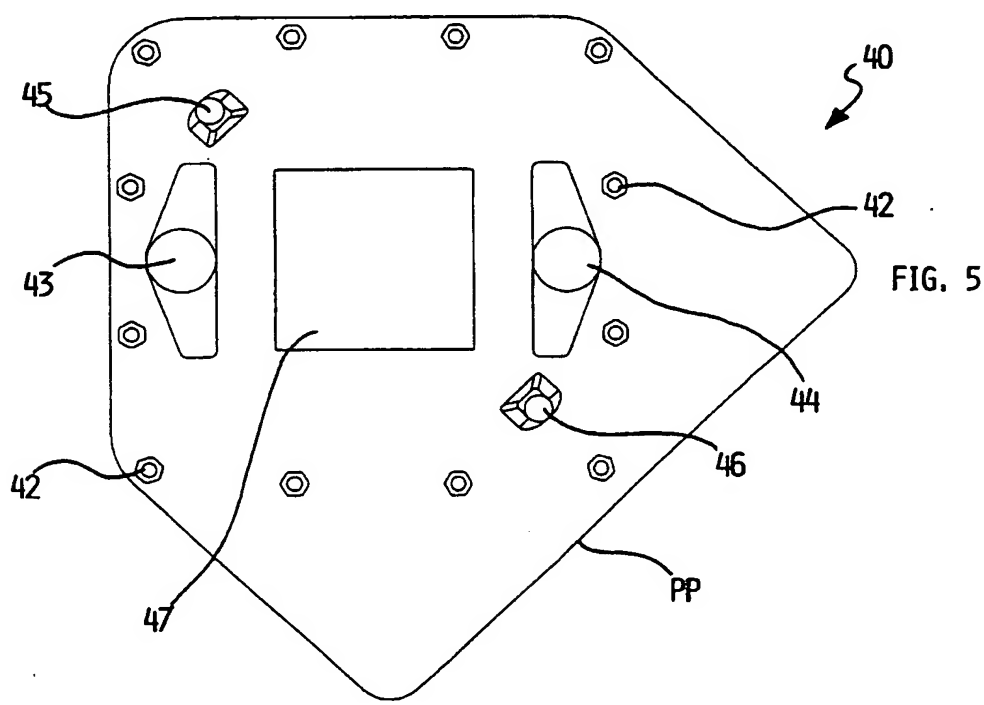


FIG. 5

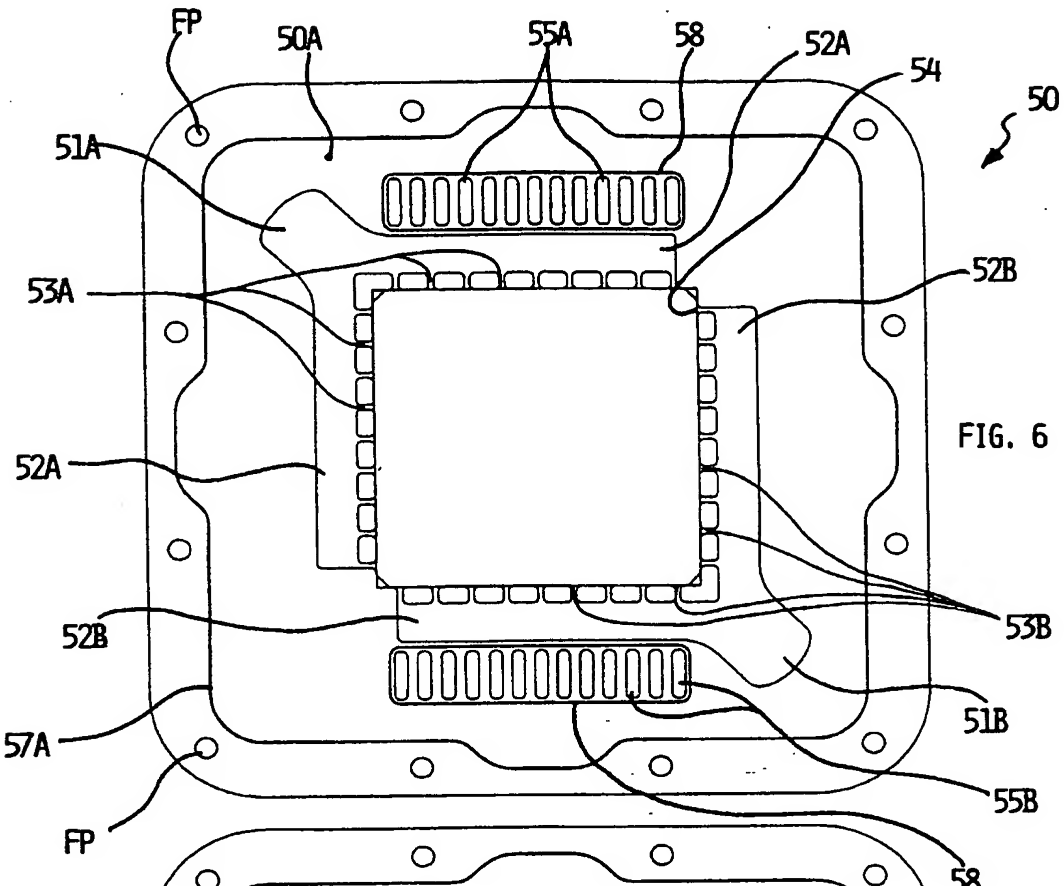

FP
50A
55A
58
52A
54
50
51A
53A
52B
52A
52B
53B
51B
57A
55B
FP
58

FIG. 6

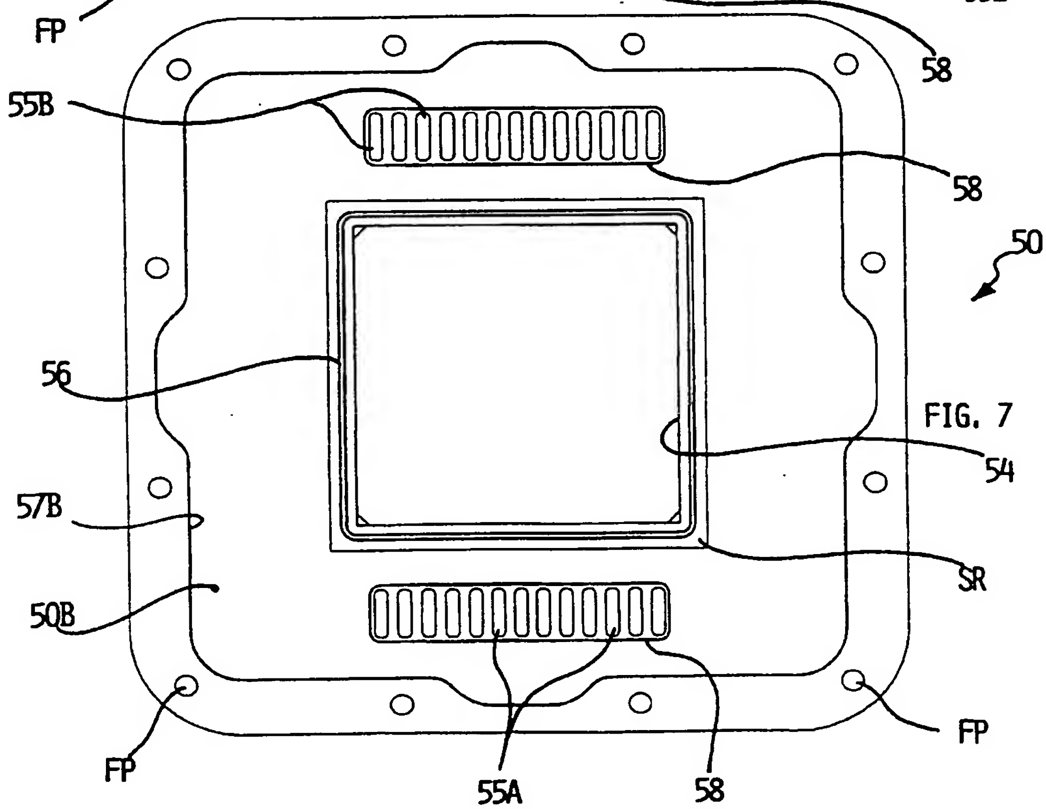
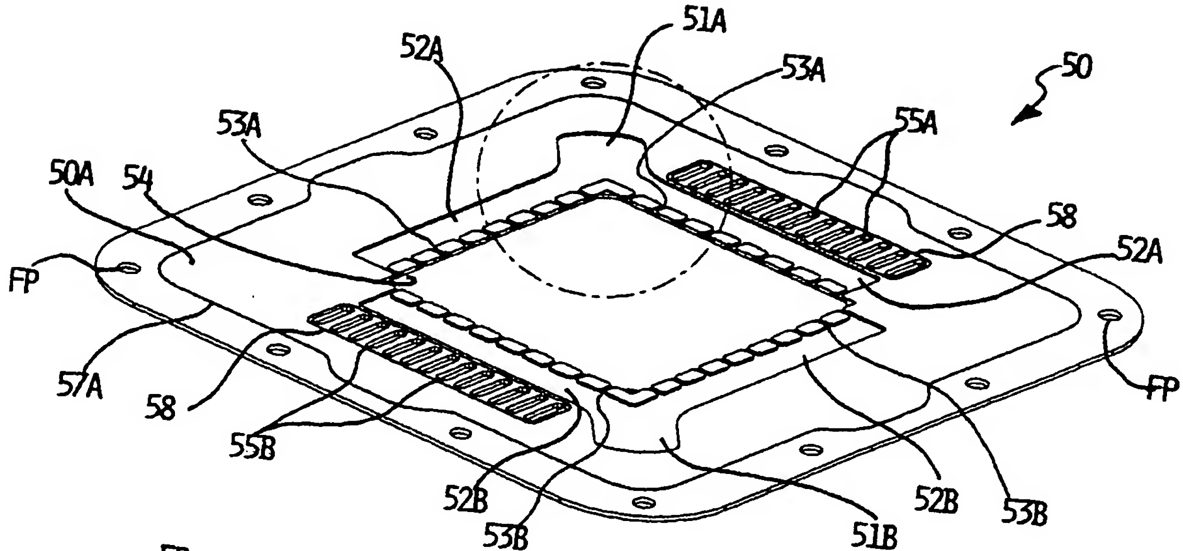

55B
58
50
56
54
57B
SR
50B
FP
FP
55A
58

FIG. 7

FIG. 8


51A
52A
53A
50
53A
55A
50A
54
58
52A
FP
FP
57A
58
55B
52B
53B
51B
52B
53B

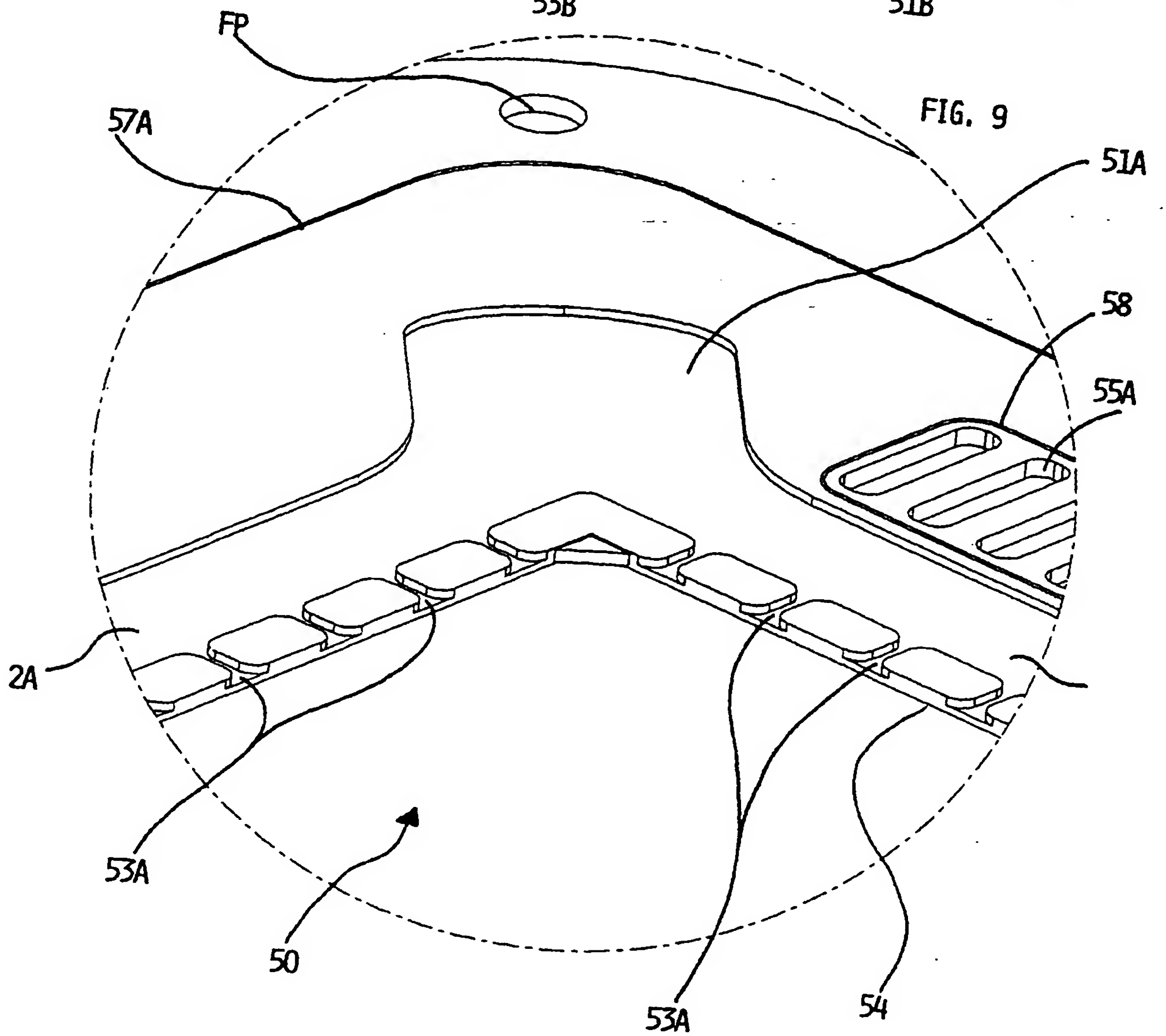
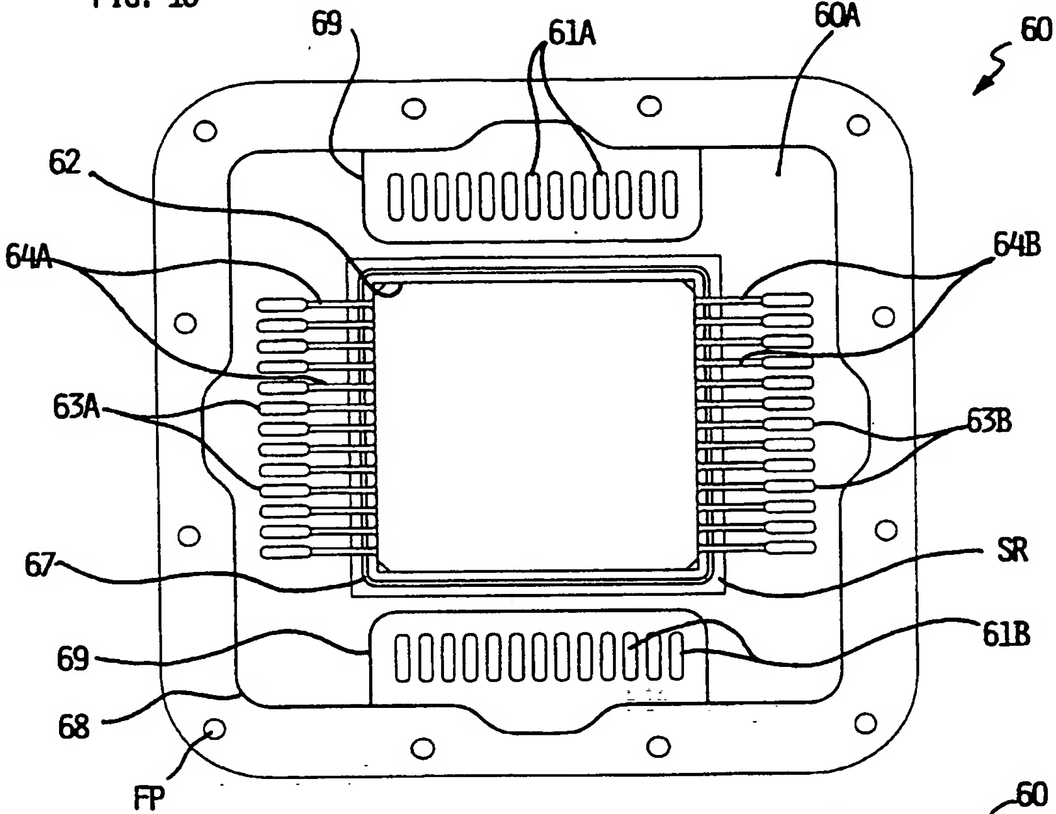

FP
57A
51A
58
55A
2A
53A
50
53A
54

FIG. 9

FIG. 10


69
61A
60A
60
62
64A
64B
63A
63B
67
SR
69
61B
68
FP

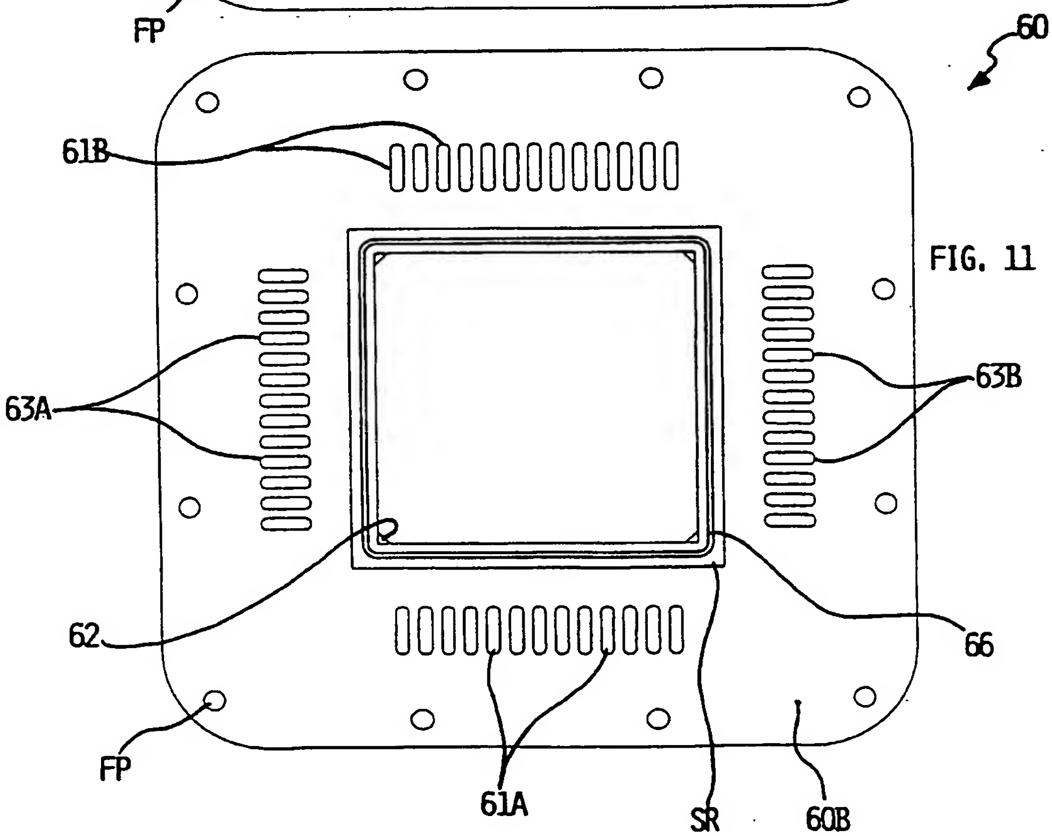

60
61B
63A
63B
62
66
FP
61A
SR
60B

FIG. 11

FIG. 12

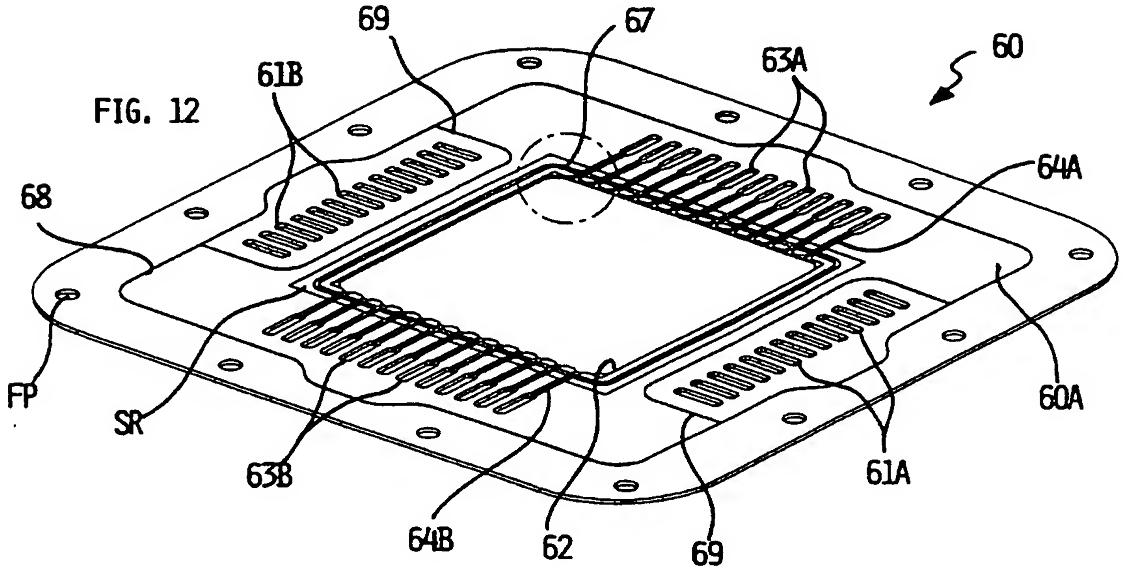

69
67
60
61B
63A
64A
68
FP
SR
60A
63B
61A
64B
62
69

FIG. 13

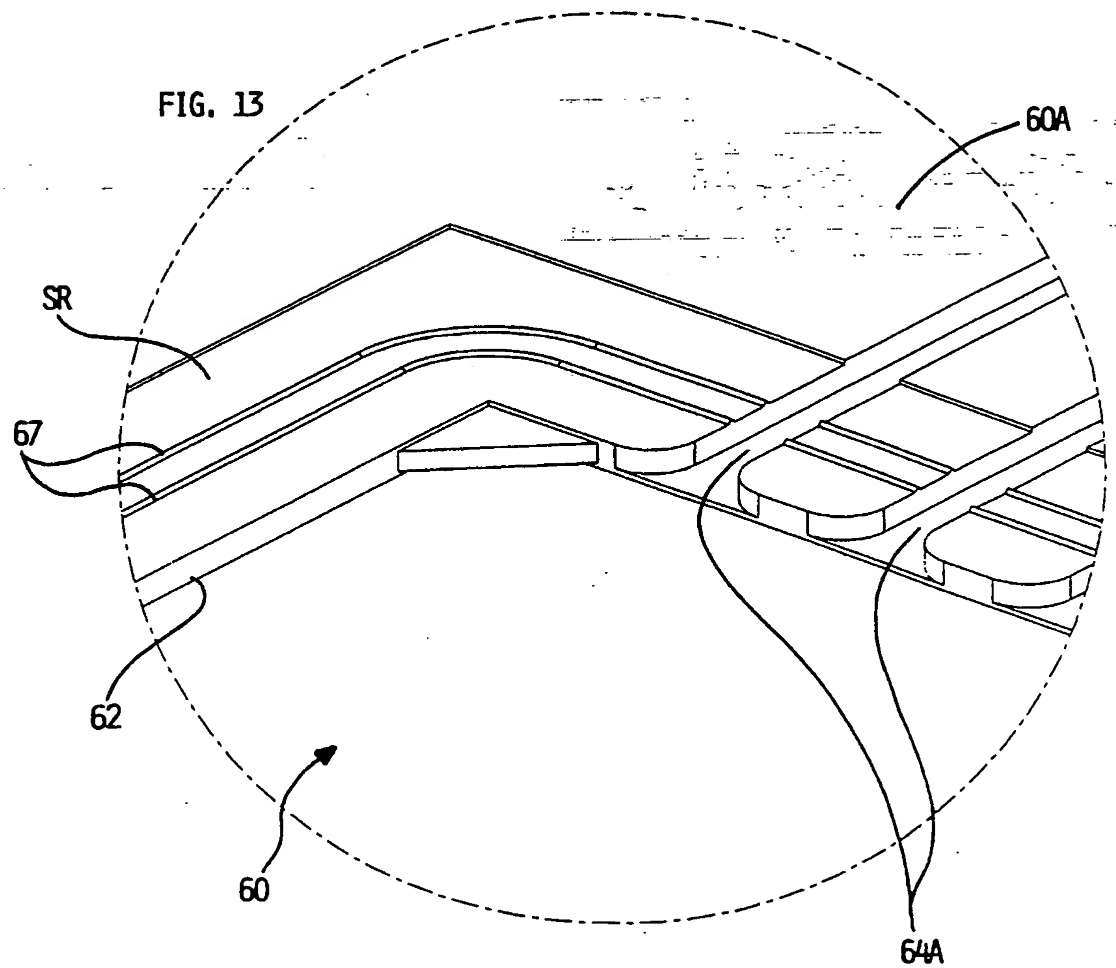
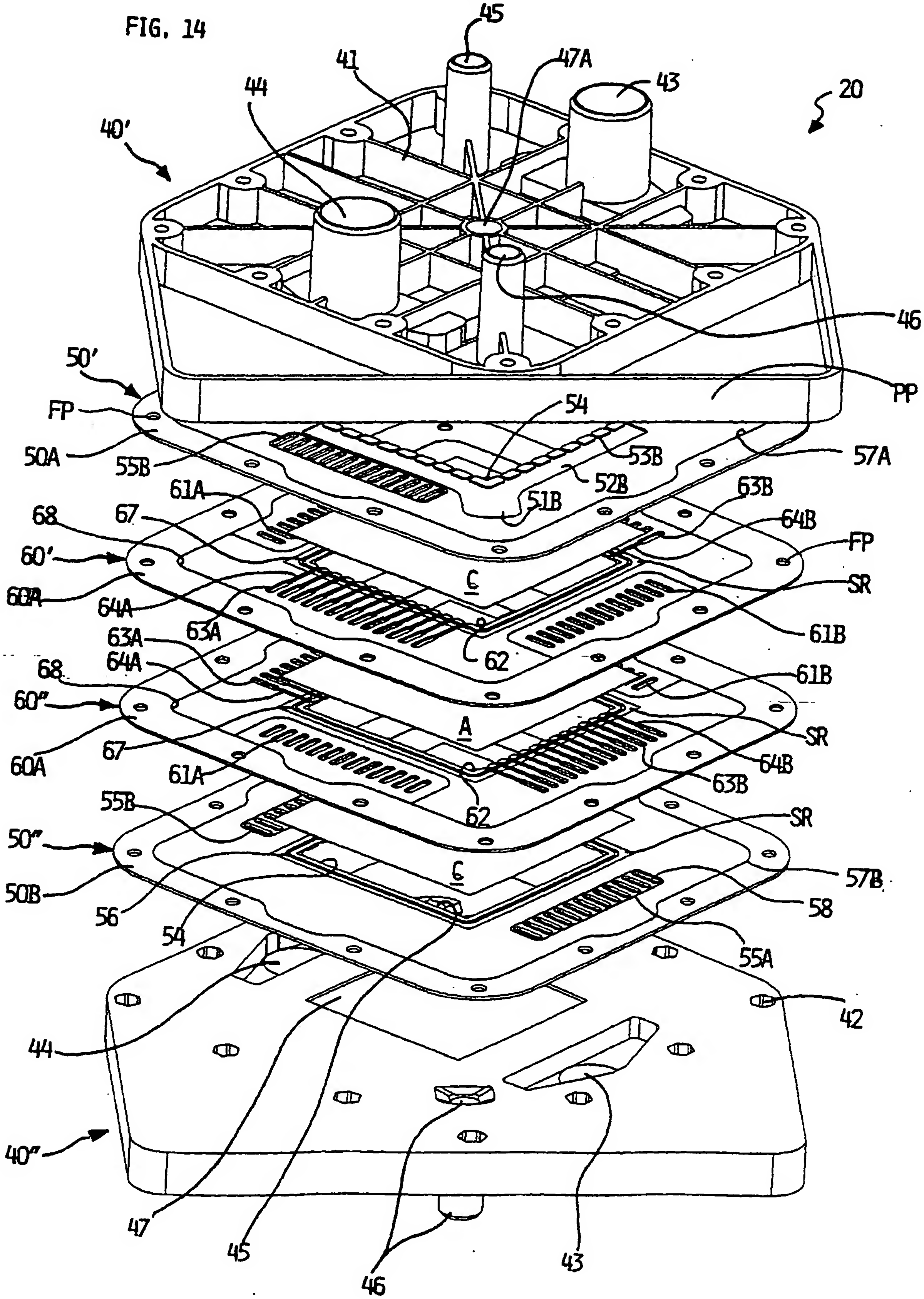

60A
SR
67
62
60
64A

FIG. 14


45
41
47A
43
20
44
40'
46
PP
50'
FP
54
50A
55B
53B
57A
52B
61A
51B
63B
68
67
64B
60'
FP
C
60A
SR
64A
63A
61B
62
63A
68
64A
61B
60"
A
SR
60A
67
64B
61A
63B
62
55B
SR
50"
C
57B
50B
56
58
54
55A
42
44
40"
47
45
46
43

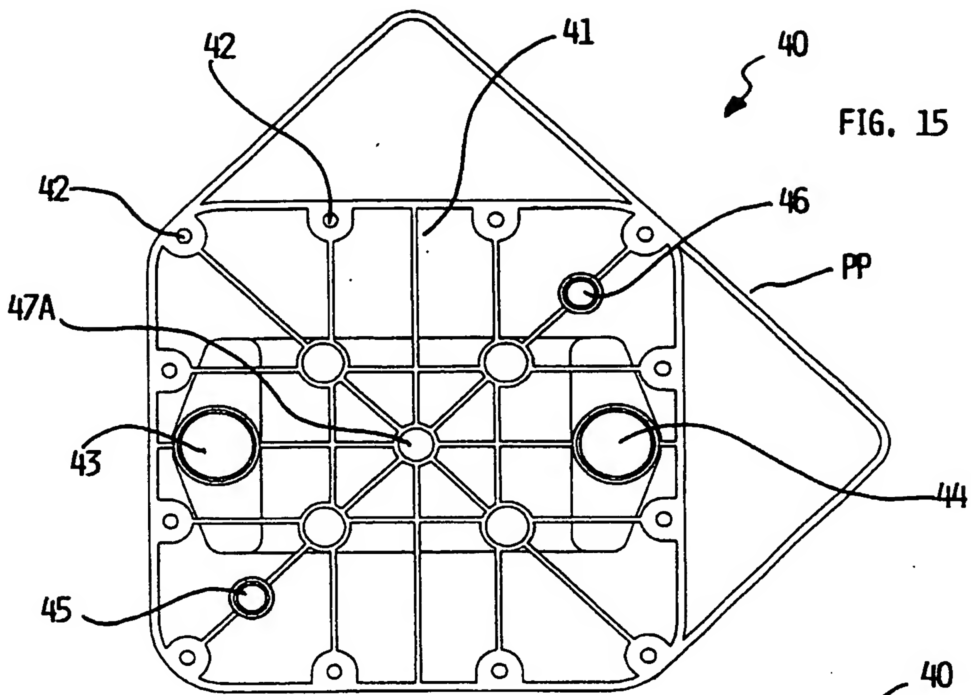


FIG. 15

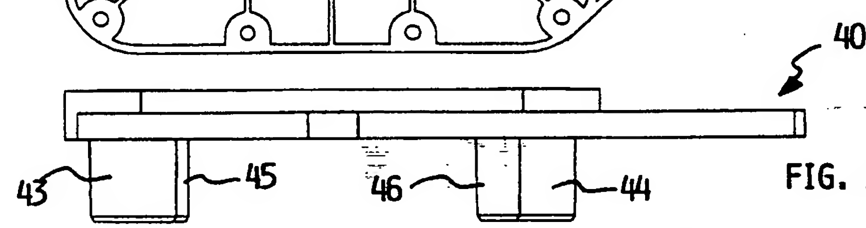


FIG. 16

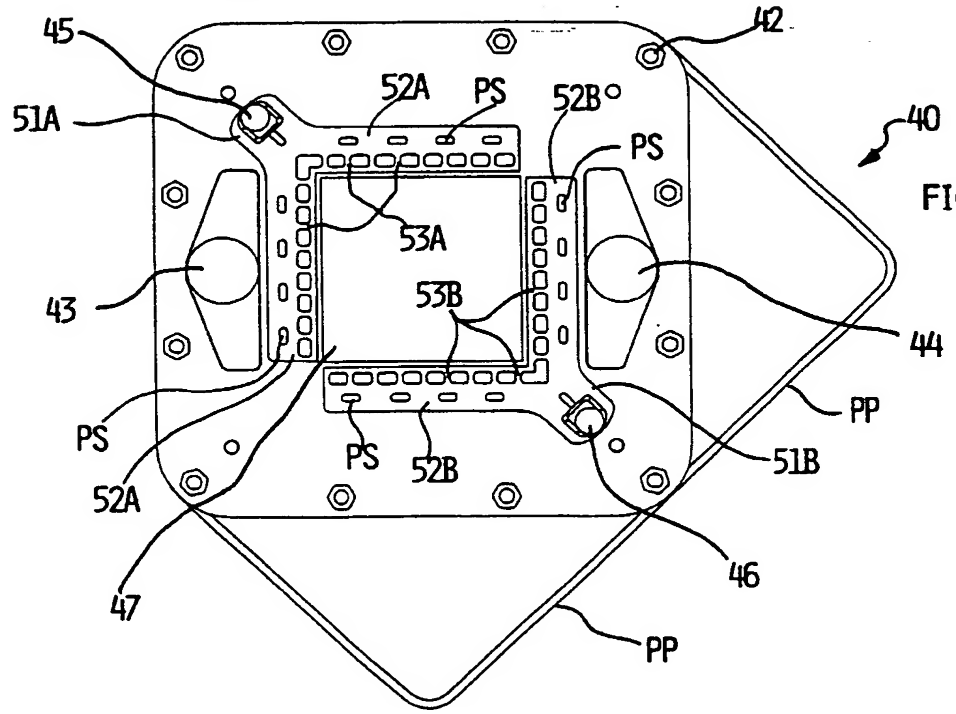


FIG. 17

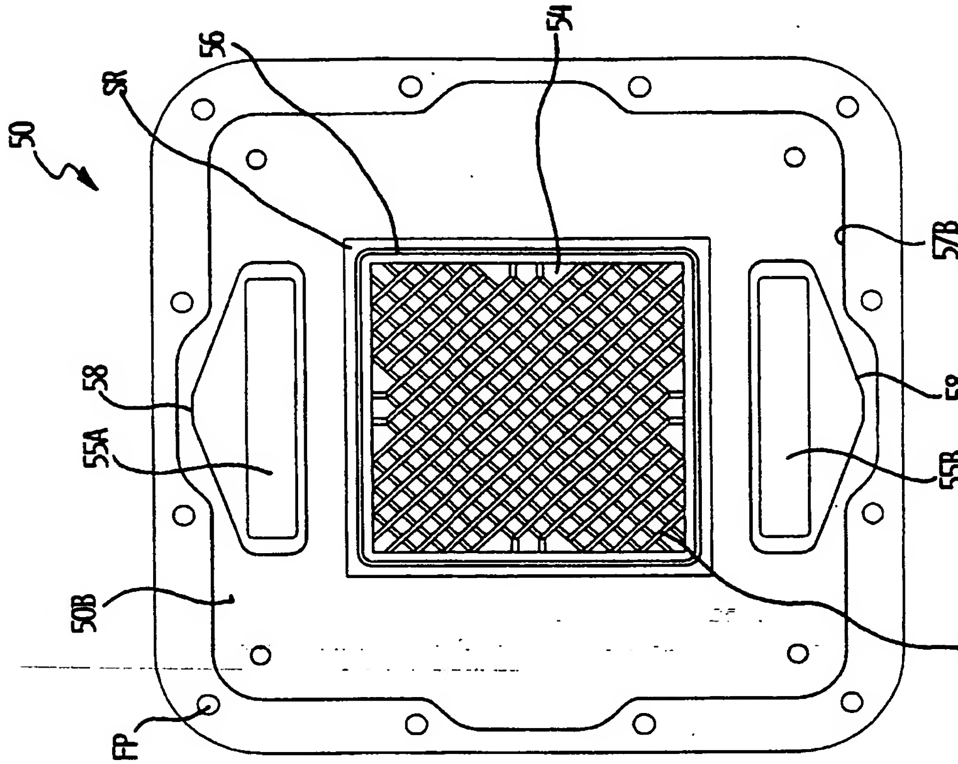

50
SR
56
54
57B
58
55A
58
55B
50B
RD
FP

FIG. 19

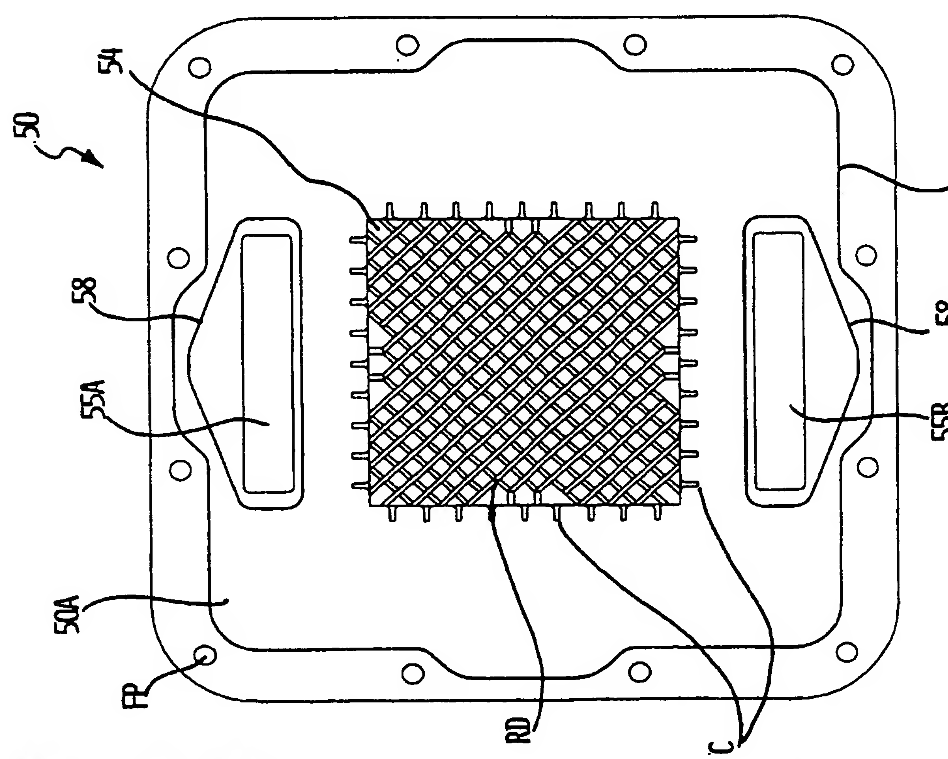

50
54
57A
58
55A
58
55B
50A
FP
RD
C

FIG. 18

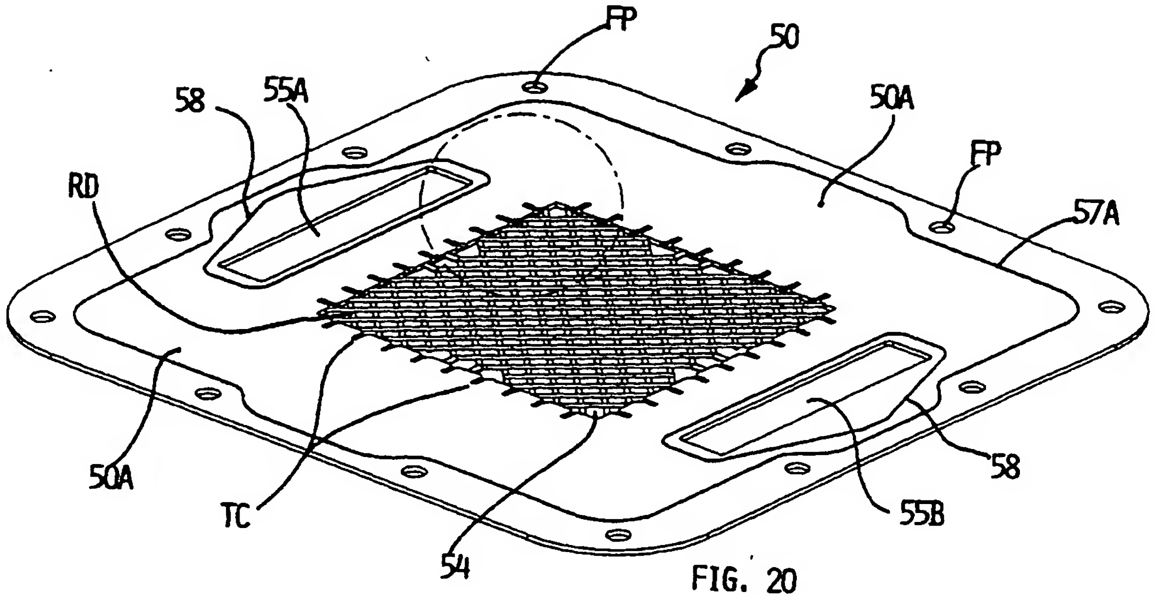
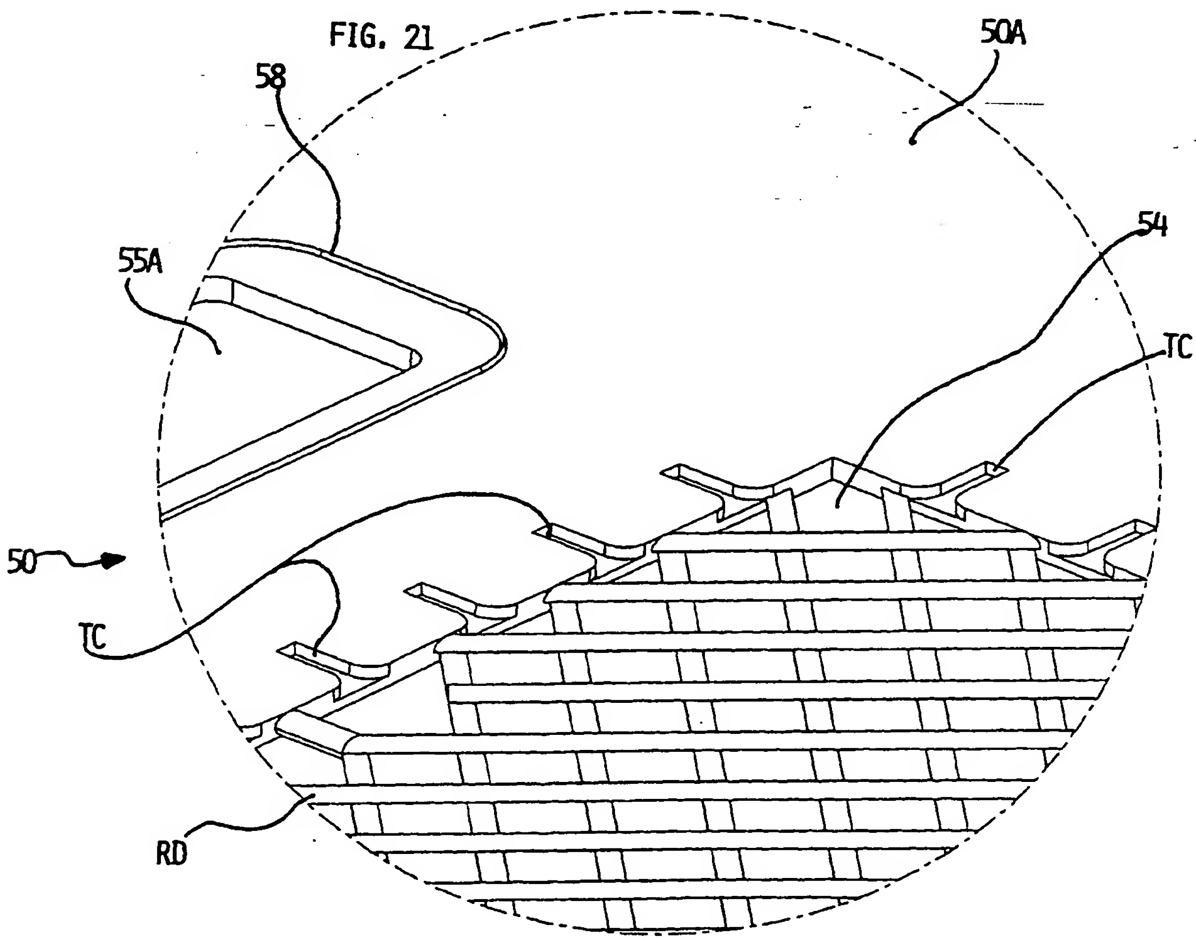


FIG. 20

FIG. 21



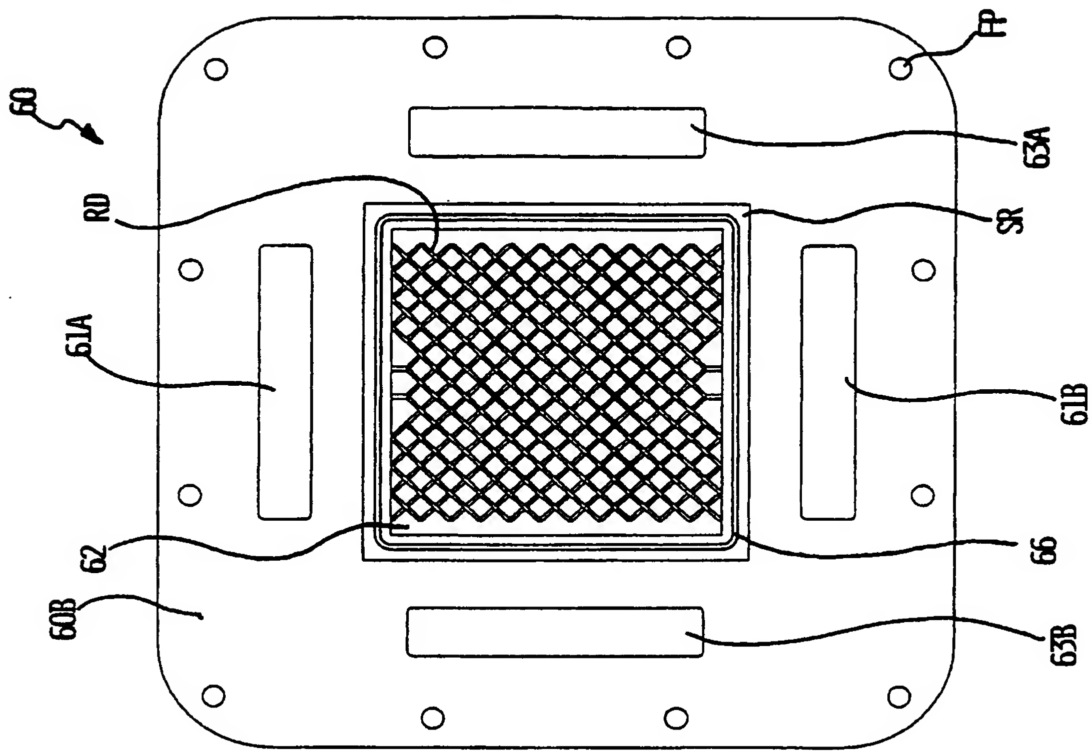

60
RD
61A
62
60B
FP
63A
SR
61B
66
63B

FIG. 23

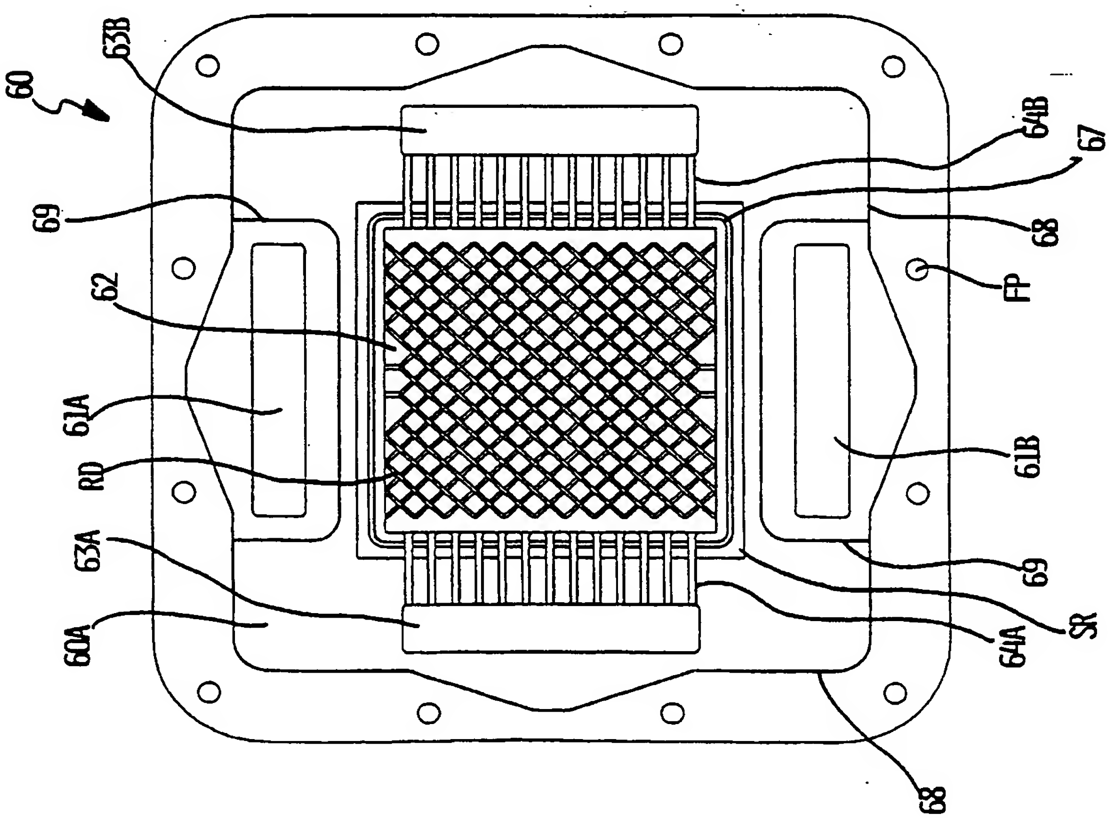

60
63B
69
62
61A
RD
63A
60A
64B
67
68
FP
61B
69
SR
64A
68

FIG. 22

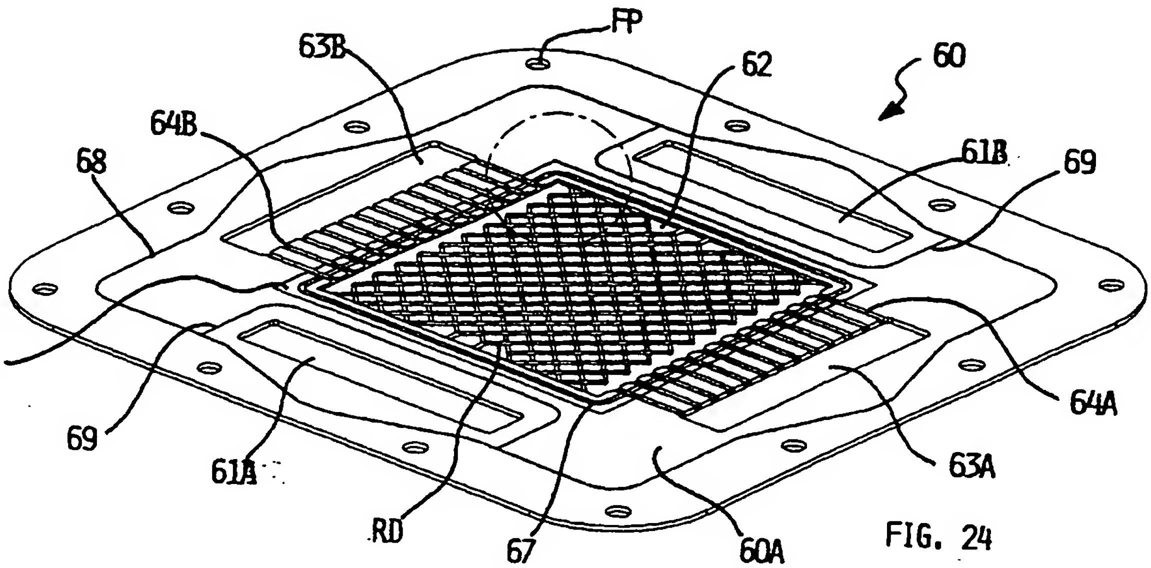
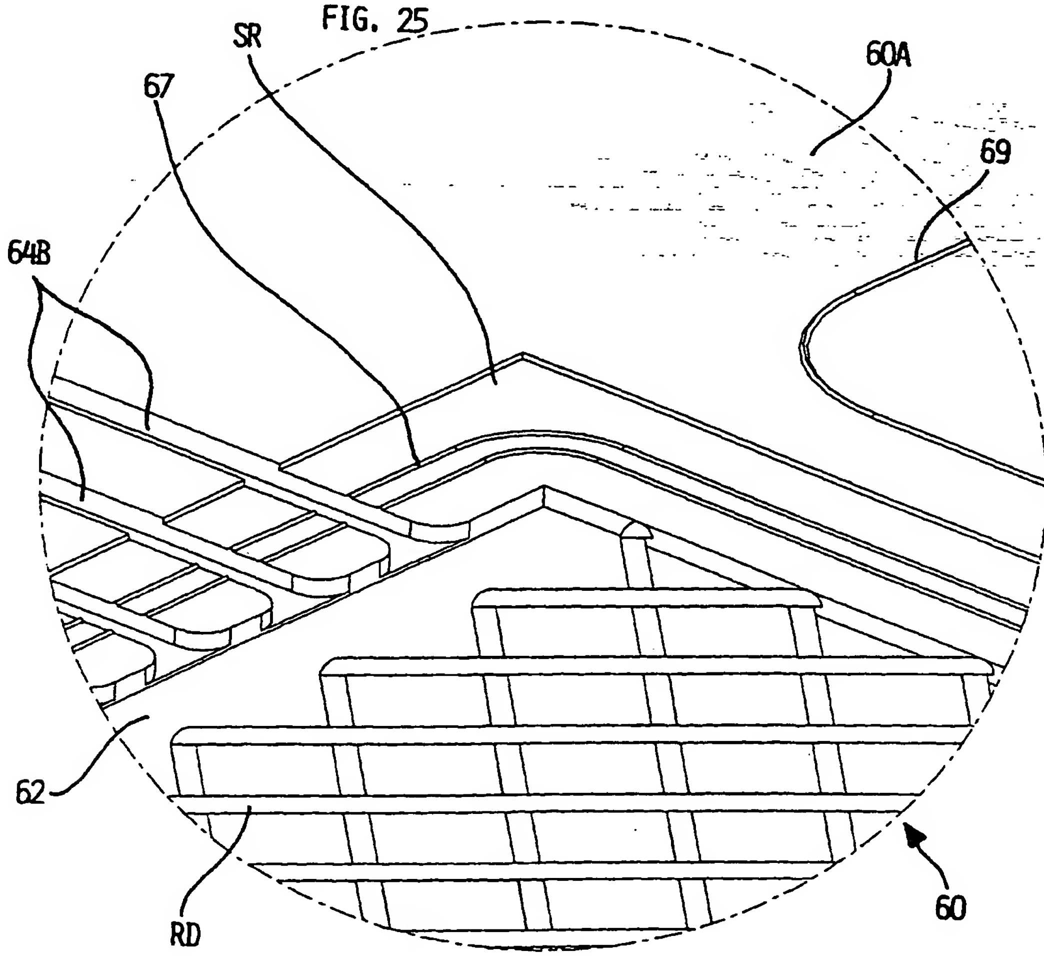
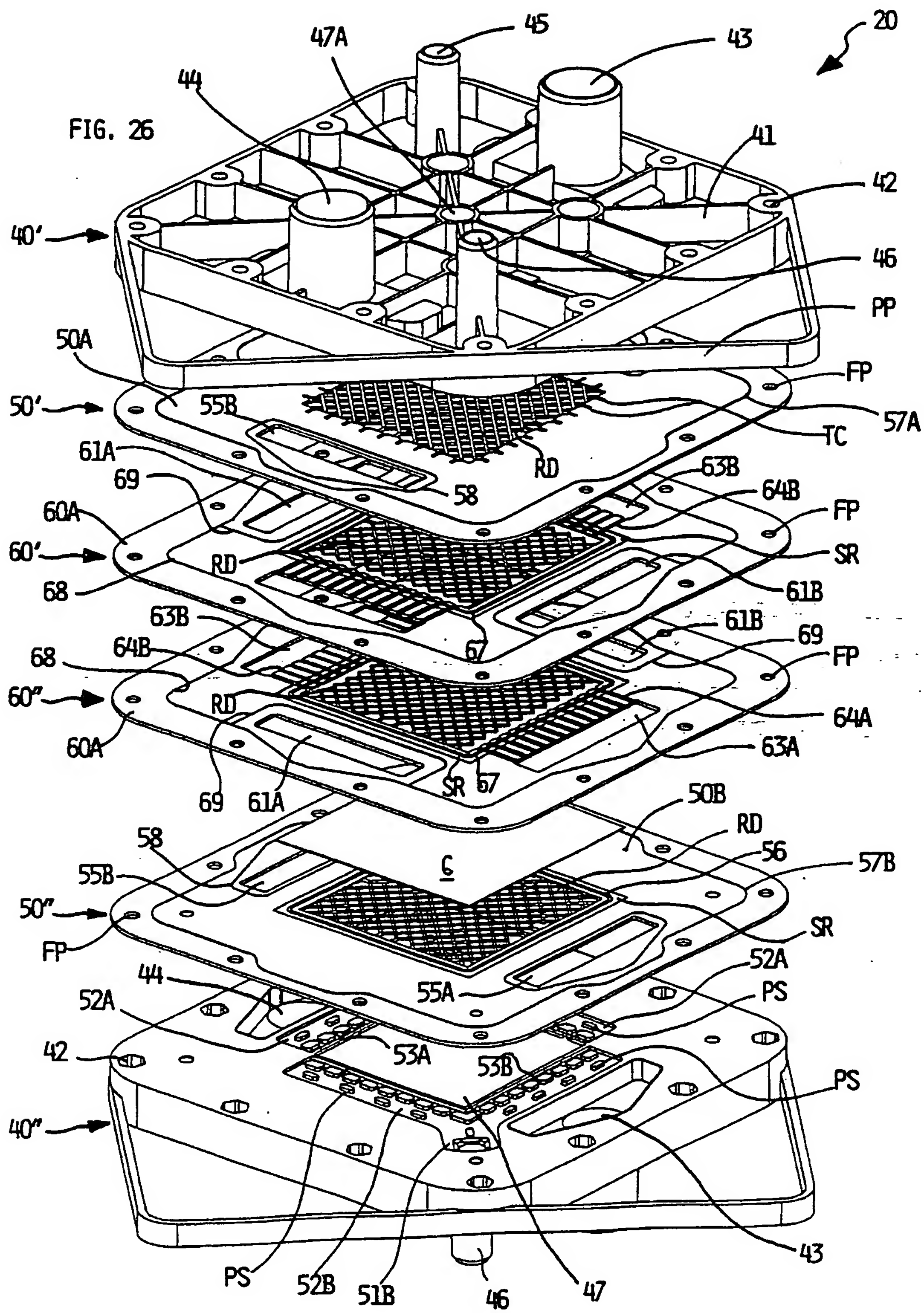

FP
63B
62
60
64B
68
61B
69
SR
69
61A
RD
67
60A
63A
64A

FIG. 24

FIG. 25


SR
60A
67
69
64B
62
RD
60


20
45
47A
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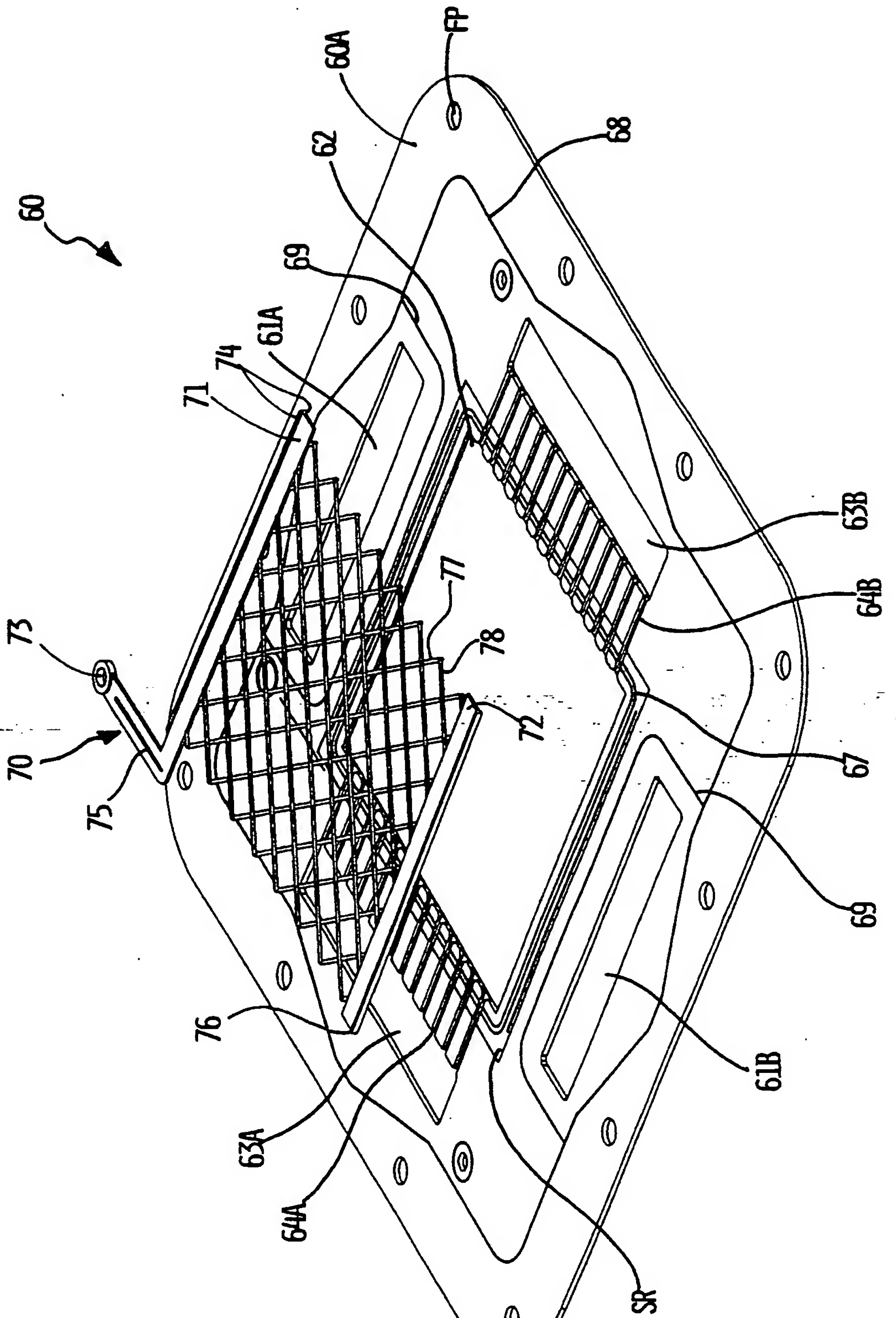
44
41
42
40'
46
PP
50A
FP
50'
55B
57A
TC
RD
61A
58
63B
69
64B
60A
FP
60'
RD
SR
68
61B
67
63B
61B
69
68
64B
FP
60"
RD
64A
60A
63A
SR
67
69
61A
50B
RD
58
56
57B
55B
C
50"
SR
FP
52A
44
55A
52A
PS
42
53A
53B
PS
40"
PS
52B
51B
46
47
43

FIG. 26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60A
FP
68
62
69
61A
74
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75
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78
72
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63B
64B
69
61B
76
63A
64A
SR

FIG. 27

FIG. 28

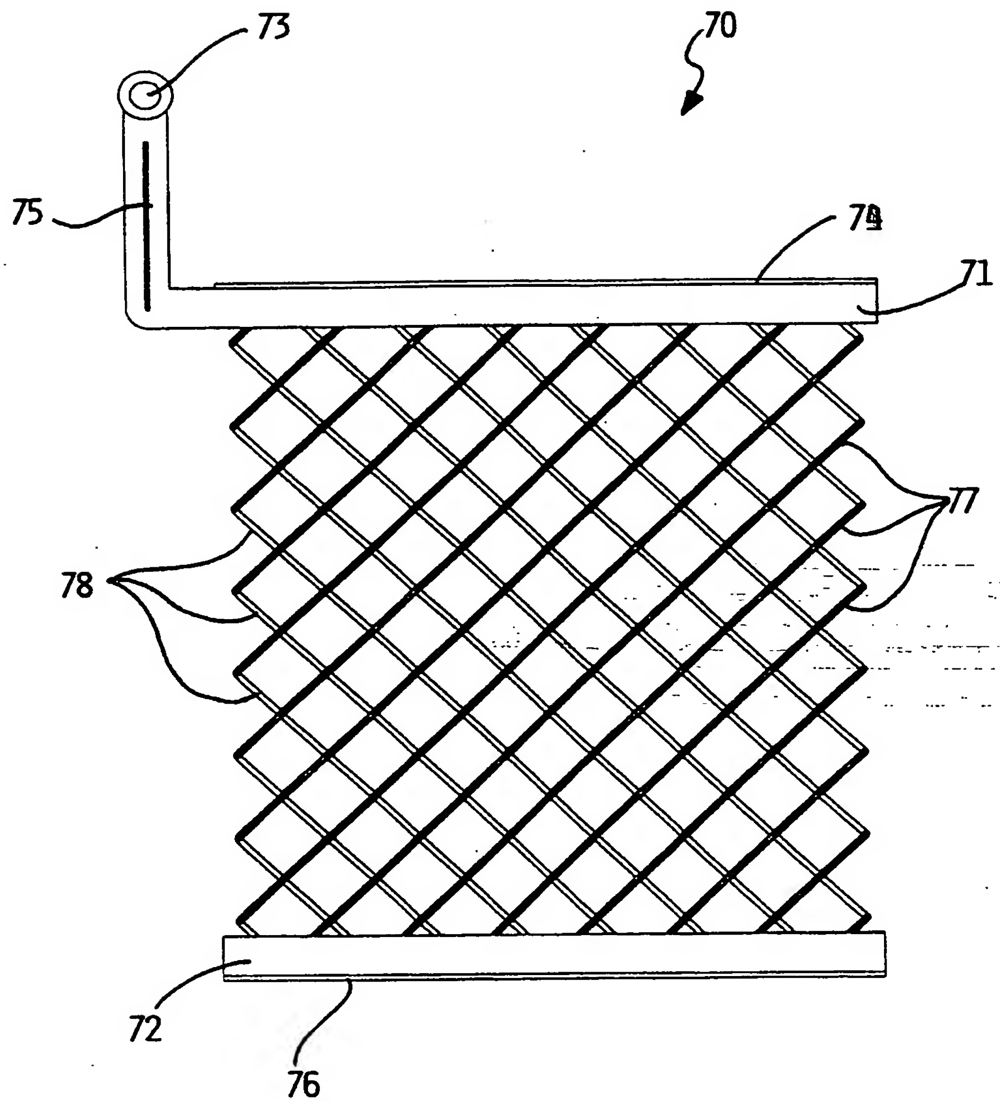
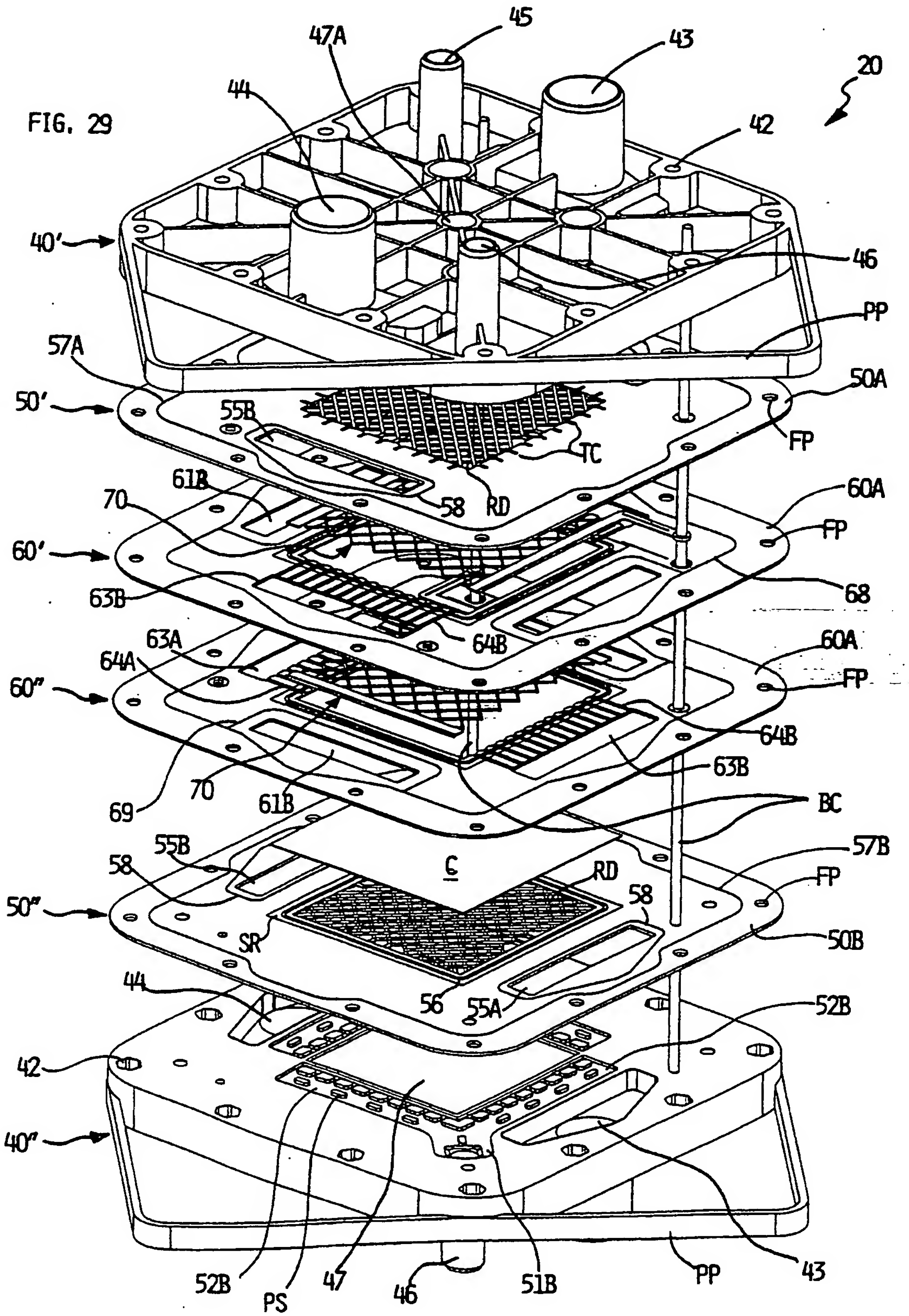


FIG. 29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47A
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20
44
42
40'
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57A
50A
50'
55B
FP
TC
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RD
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60A
70
FP
60'
68
63B
64B
63A
60A
64A
FP
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64B
63B
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69
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BC
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57B
58
C
RD
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47
46
51B
PP
43

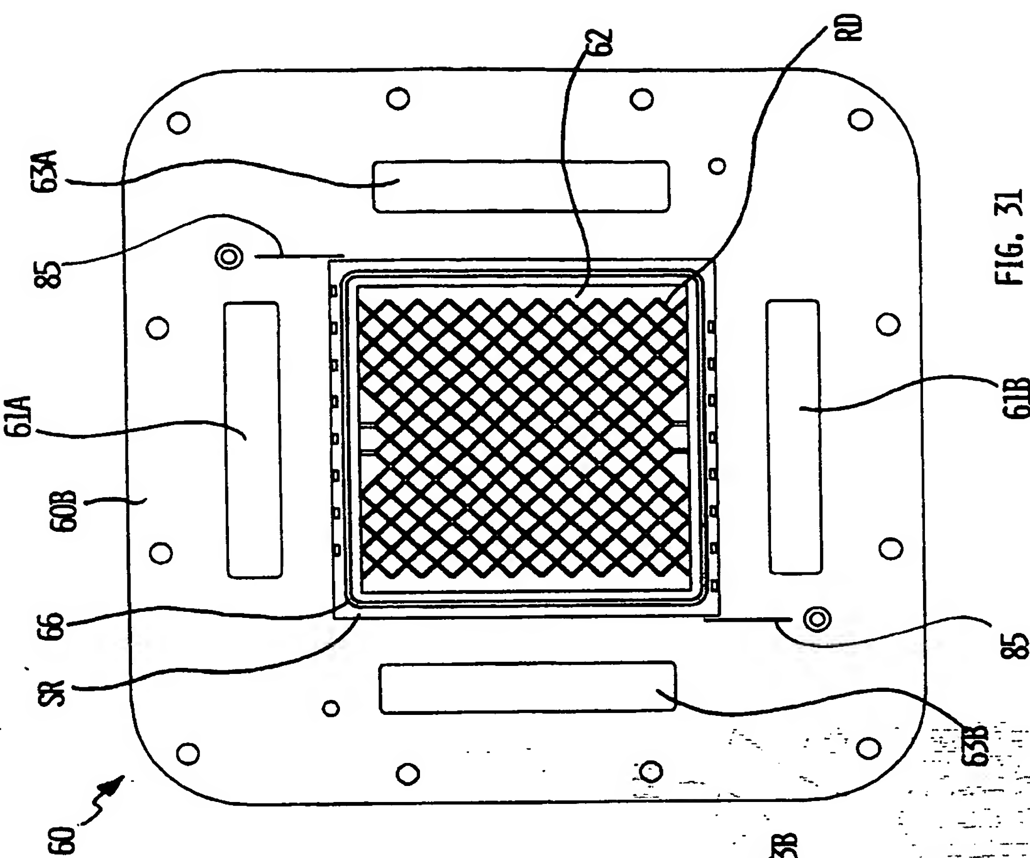
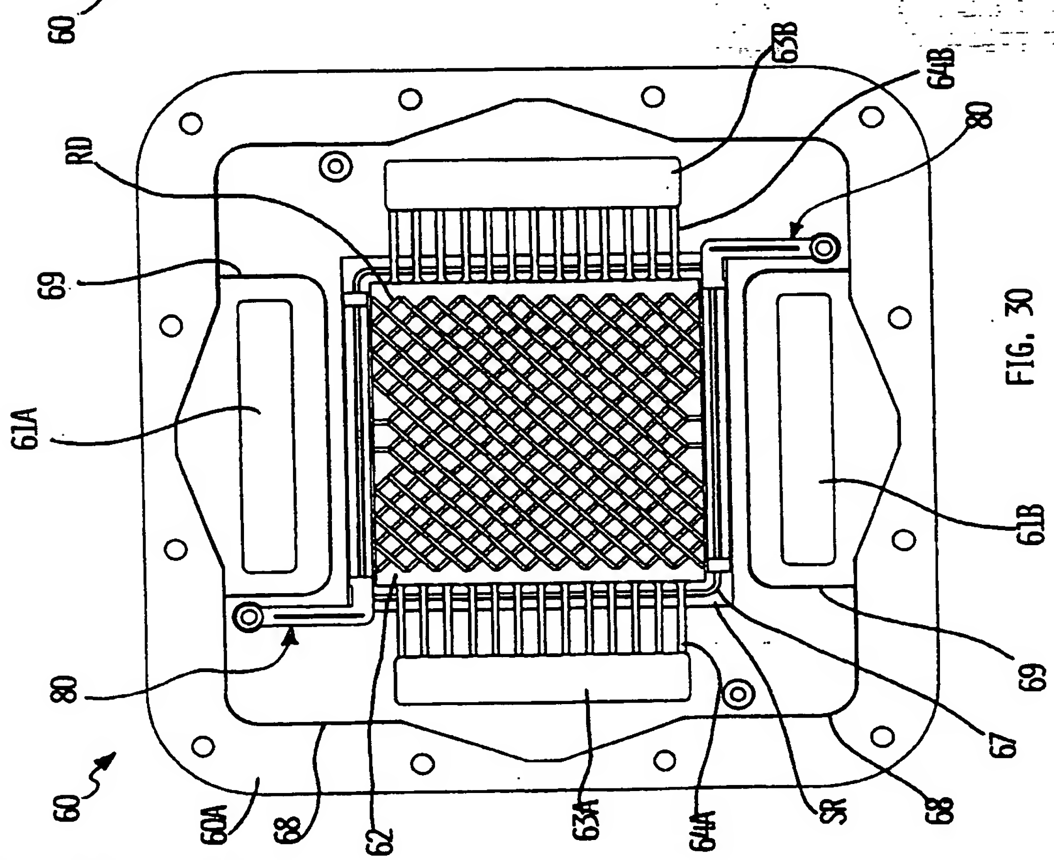

62
RD
63A
85
61A
60B
66
SR
60
61B
85
63B

FIG. 31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60A
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SR
68
63B
64B
80
61B
69
67

FIG. 30

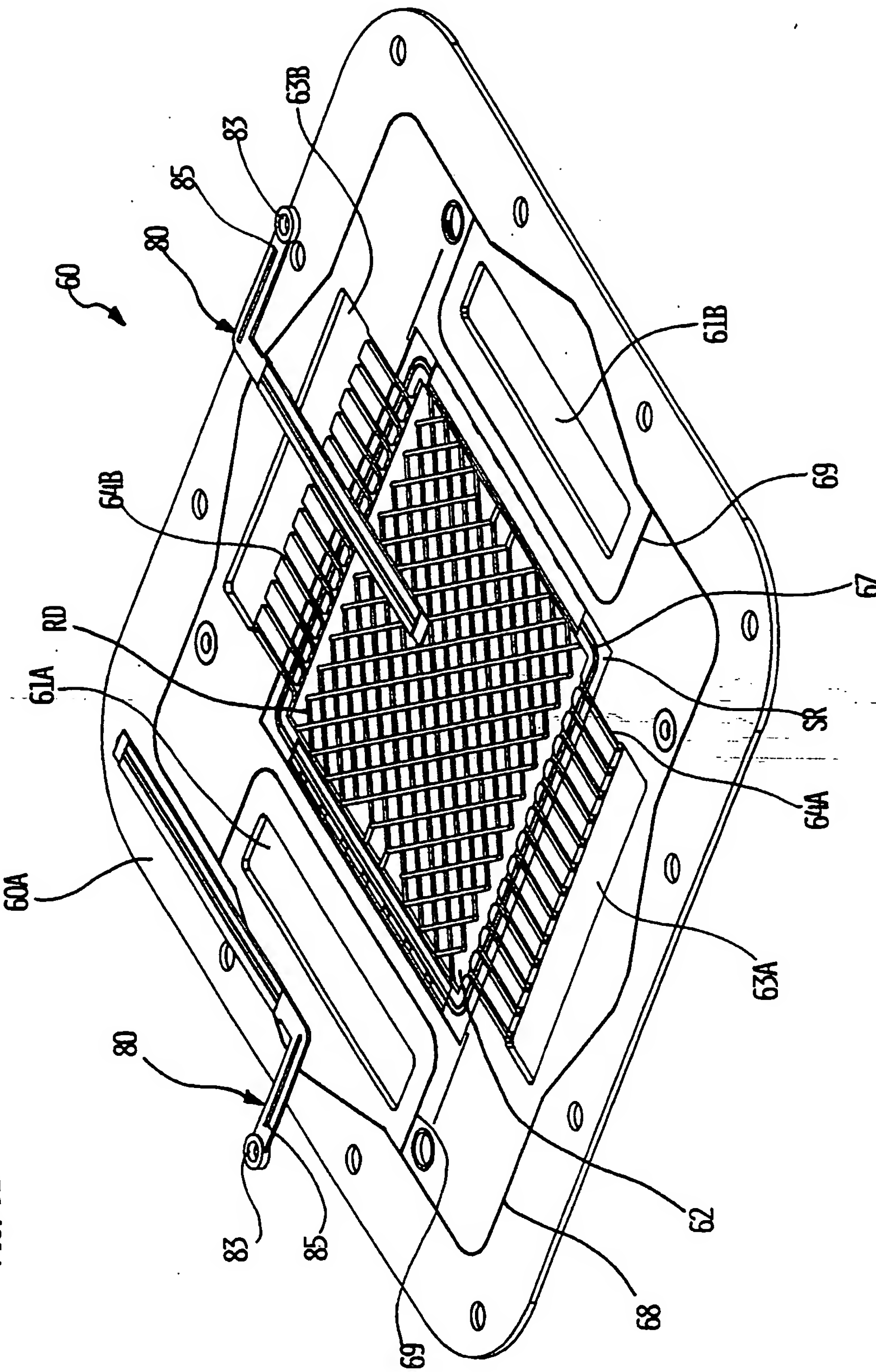
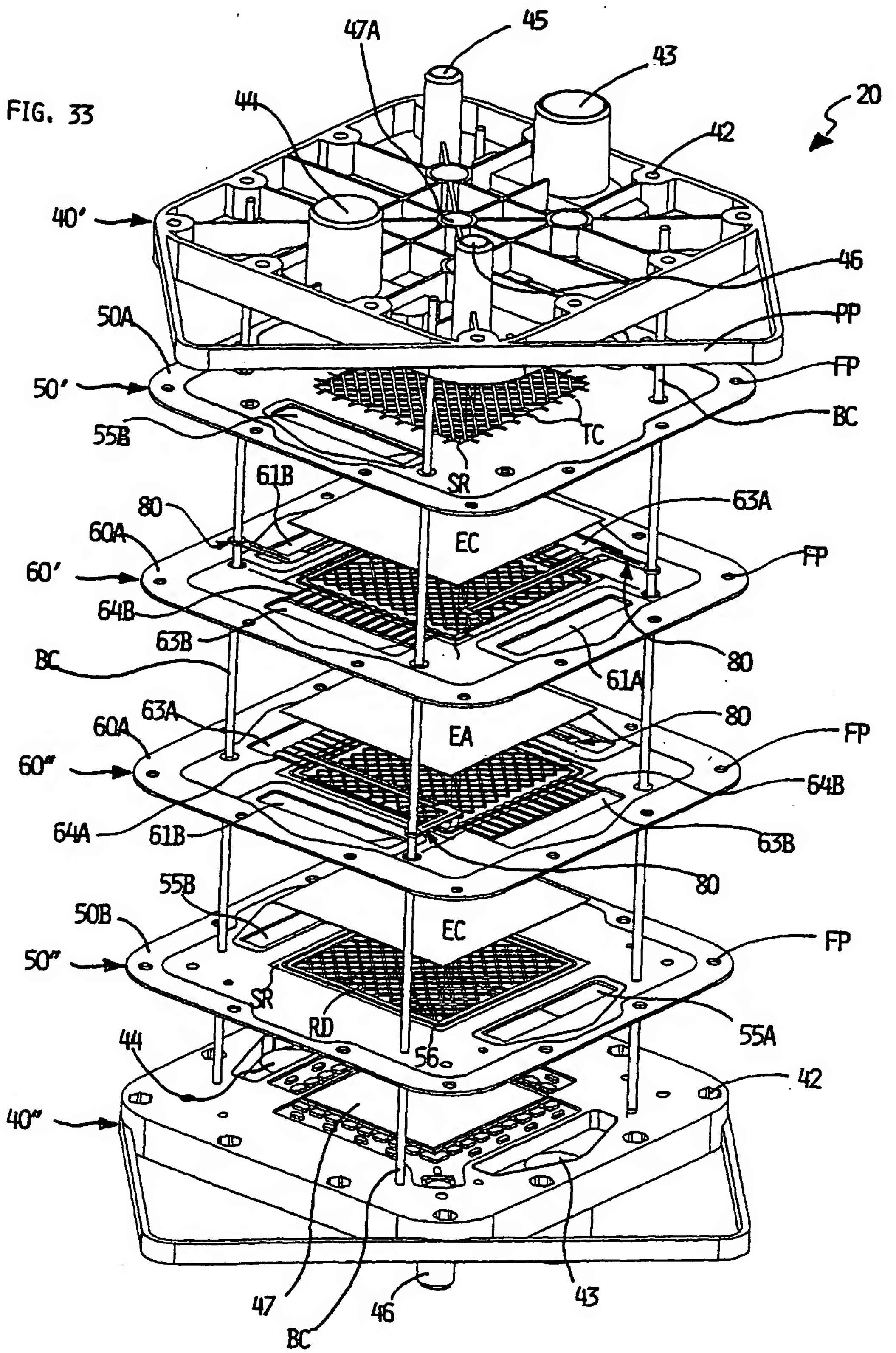


FIG. 32

FIG. 33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47A
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50'
FP
BC
55B
TC
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63A
80
EC
60A
60'
FP
64B
63B
BC
80
61A
63A
80
60A
EA
FP
60"
64B
64A
61B
63B
80
55B
EC
50B
FP
50"
SR
RD
55A
44
56
42
40"
47
46
43
BC